MEMOIRS

OF

THE GEOLOGICAL SURVEY OF INDIA.

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VOLUME XXXVIII.

THE KANGRA EARTHQUAKE OF 4TH APRIL 1905. BY C. S. MIDDLEMISS, B.A., F.G.S., *Superintendent, Geological Survey of India.*

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C. S. Middlemiss, Photo.

GOLDEN TEMPLE, KANGRA BHAWAN.

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INTRODUCTION.

Preliminary Report.

A preliminary account of this earthquake has already appeared in the publications of this department.[1] To save repetition the reader is referred to it for a brief narrative and summary of the main effects of the shock.

Scope of present work.

The present larger work is an attempt to bring together a full descriptive record of such of the phenomena of the earthquake as have, or may have, a scientific bearing. In it the recording and arranging of facts observed at first-hand, and of well-authenticated evidence, hold the most prominent place, and constitute the bulk of the volume.

First-hand observations, and local reports.

As regards first-hand observations, no more need be said than that they were carried out by my colleagues, Messrs. Simpson, Pascoe and Hallowes, and myself, by means of personal traverses over certain selected parts of the affected area; and therefore it is hoped that they are as reliable as any other coordinated scientific work. As regards evidence, it always happens in the case of a large earthquake that enormous areas remain over which cannot be visited by experts, and for these it becomes necessary to weigh quantities of uncoordinated evidence derived from local sources. In the case of this earthquake such evi-

[1] Rec. G. S. of I., Vol. XXXII, pt. 4.

dence has been furnished by a great many local observers scattered all over India[1] by means of the filled-in earthquake question-forms. From these I have drawn freely for my information, especially where no first-hand information was available ; and their assistance in building up an account of the earthquake has been invaluable. But at the same time I have found it impossible to quote everybody and everything ; partly because over many areas the same phenomena are repeatedly referred to in the same way by many observers, and partly because a great deal of the information is of such a nature that it loses cogency by the side of more definite, though much simpler facts. It is nevertheless to be hoped that all those patient contributors who have assisted me in collecting the material for this report, but whose remarks have gone without mention in this book, will not on that account conclude that their work was useless. On the contrary, in matters of evidence it is just by means of a wealth of repetition and corroboration of certain phenomena, that a compiler can feel what is the next best thing to an absolute certainty with regard to them—which he could not do on the strength of only one or two, often imperfectly agreeing, accounts.

From the cheerful and frequently painstaking way official and non-official contributors have sent in their experiences, one may deduce the dominant, and I think correct, point of view, that a destructive earthquake, being a universal misfortune, imposes the moral obligation on all to unite in doing their best to understand it ; inasmuch as such an attempt is the first step in the direction of prevention, or at least mitigation, of its horrors.[2]

Earthquake question-form.

For the gathering of this evidence from all available parts of India where the earthquake was felt, a printed question form containing a request for information on the following points was issued urgently by the Director of the Geological

[1] See list of names at end of Part I.

[2] Owing at least largely to the time of the earthquake, but also to its severity and suddenness in the more central areas, this earthquake was more than 10 times as disastrous to life as the Assam Earthquake of 1897. About 20,000 human beings are estimated to have perished by it.

Survey on the 6th instant, two days after the shock, and distributed officially all over the area likely to have been affected. At the same time an abbreviated question-form was sent to the chief newspapers calling for similar information :—

1. Full name and address of observer, given in sufficient detail to permit of adequate acknowledgment in published reports.

2. Place and district in which the observations were made.

3. Date on which the observations were first recorded in writing.

4. Situation of the observer :—

Please state whether you were—

(*a*) indoors when the shock was first felt ;

(*b*) in the open air ;

(*c*) lying down, sitting, standing or moving.

5. *Time* at which the shock was felt. Please state precisely the means by which the time was observed, that is, whether merely guessed, whether recorded at the moment by watch, and whether the watch was compared with a clock known to keep a recognized standard time, such as the clocks kept at railway and telegraph offices.

6. *Number of distinct shocks* :—

(*a*) Particulars of any tremulous vibrations, not distinguishable as separate movements which occurred before the principal and distinctly noticeable to-and-fro movements.

(*b*) The number of principal and prominent shocks felt, the intervals in seconds between them and the order of their intensity.

(*c*) Existence of tremulous vibrations after the principal shocks and the time of their duration.

7. *Apparent direction of shocks*, judged by the fall of loose objects, hanging lamps, or movements of water in tanks and bath-tubs.

8. *Sound phenomena.*—Please state the nature of any sounds noticed before, during or after the main shocks : and, if possible, state the interval in seconds between the first sound and the first shock.

9. *Intensity of the shock.*—Please state whether the shock was "hardly felt" or "distinctly felt," and if the latter, please give precise details of its effects in order that an estimate may be made of its intensity at your station. No apparently unimportant detail should be omitted, as in the absence of instrumental records, this form of evidence affords the only means of tracing the curves of equal intensity, and of making the first approximate determination of the focus of disturbance.

10. *Effects of the Earthquake.*—Please give below any precise observations you have made on the following points :—

(*a*) Particulars of objects overturned, their size, position and direction of fall.

B 2

(*b*) Details of cracks in buildings, with sketches showing their directions, and an accurate record of the direction of every wall affected.

(*c*) Effects on the water of tanks and bath-tubs, giving the direction of the movement.

(*d*) Direction and amount of movement of free swinging objects, such as hanging lamps.

(*e*) Occurrence of earth-fissures, their direction and nature, with critical observations of any relative displacement of the ground on opposite sides of the fissures.

11. *Aftershocks.*—Date, time and approximate intensity of shocks noticed subsequently to the main earthquake which occurred in the early morning of April 4th, 1905.

They vary in accuracy, but are generally reliable.

That the observations entered in these forms must necessarily vary in accuracy and consequent value is obvious, since the writers vary from the completely irresponsible person through a long list of more or less sincere and careful witnesses up to the trained officers of scientific departments under the Government of India, and a small sprinkling of unofficial observers, scientific in spirit, if not by profession. In spite of a few defects of exaggeration on the one hand, and of apathetic indifference on the other, the evidence under this heading as a whole, though nowhere pretending to infallibility, may be said to convey a generally accurate picture of the visible and tangible phenomena of the earthquake; whether evanescent, such as the recorded times, sounds, number of shocks and subjective sensations; or whether of a less transitory nature, such as the damage to buildings, to communications, and to natural features of the country. Furthermore the very numerous and variously derived observations have all tended to check one another, and so eliminate any form of extreme error. The resulting body of data presented under this heading of evidence has therefore a strong warranty for being measurably, or even closely, in accordance with fact. It is fortunate that one can feel an assurance of this, for earthquake phenomena, even of the less transitory kind, soon become obliterated by time; and no corroboration or revision of observations is possible in later years, as it is for instance in the case of ordinary geological data.

How the present work is divided.

In the following pages, Part I has been devoted to a detailed description of all the impressions and effects of the earthquake as recorded both by the officers specially deputed to examine it, and also by the local observers through the medium of the earthquake-forms. It is divided into four chapters as follows :—Chapter I contains a description of the larger of the two epicentral areas, namely, that of the Kangra Valley and Kulu. For this I have trusted mainly to my own observations during my two months' tour through the region ; only supplementing it by evidence derived from the earthquake-forms and from newspaper reports. Chapter II contains a description of the smaller epicentral tract of Mussoorie and Dehra Dun. For this the reports of Messrs. Simpson and Hallowes have been of first importance, supplemented as before by evidence from the earthquake-forms and newspapers. Chapter III contains a description of the area embraced by the large cities of the plains in the vicinity of isoseismal No. 7. For this Mr. Pascoe's report has been of first importance, supplemented as before by the earthquake-forms and newspapers. Chapter IV contains a description of the remaining areas where the earthquake was sensibly felt. For this the material at my disposal has been entirely derived from the earthquake-forms, newspapers, etc. Part II is divided into two chapters, the first of which under seven sub-headings discusses certain of the more prominent features of the earthquake as embodied in the earlier descriptive part, and attempts to generalise concerning them. The last chapter is devoted to the foreshocks and aftershocks of the big event.

Delay in publication.

A word or two is perhaps necessary on my part in explanation of the delay which has occurred in the compiling of this memoir. It was interrupted by a period of six months leave to England in 1906, and later by a year's charge of current duties in the office of the Survey, duties which every year become heavier and leave little time, except holidays and overtime for original or compilatory work. Concurrently during this period I had charge of the Central India and Rajputana field party, and was

personally engaged in survey work myself there and elsewhere during much of the time.

Co-operation of other departments.

As most of the material for this memoir had to be collected rapidly in the central areas of devastation and at a time of great public stress; whilst all the rest of the material (as represented by the earthquake-forms) had to be arranged for through the various local Governments and Native States; it must be apparent that this department was greatly dependent on the co-operation of many other departments and individual officers therein, as well as on that of a variety of private individuals who were public-spirited enough to assist. All the important newspapers of India also assisted by publishing a series of questions similar to those given at p. 3.

Thanks.

It would be impossible to name all these, and I must therefore be content to thank in a body all members of the various civil departments under Government, officials of Native States, the officers of the Gurkha regiments at Dharmsala and other regiments quartered in the less seriously affected part of the area, all editors of newspapers and many private persons for their generous assistance to me in carrying out the field work or in otherwise gathering data for this book.

PART I.

RECORD OF OBSERVATIONS.

CHAPTER I.

KANGRA KULU EPICENTRAL AREA.

This portion of the country affected by the earthquake fell to my lot to investigate. It will be well at the outset to indicate briefly the route taken. (See map, Pl. 30.)

Route followed by the author

I first proceeded to Lahore, where I halted to consult the local Government, and also to meet my colleague Mr. Pascoe, and arrange for his separate sphere of work. From Lahore I took train on 12th April to Pathankot, the nearest railway station to the centre of damage: thence by *tonga* (mail cart) to Shahpur, situated among the foot hills of the Sub-Himalaya, which was then a busy base of operations for relief and reconstruction parties. From Shahpur I proceeded to the heart of the convulsed area at Dharmsala and Kangra, where I spent eight days investigating the terrible effects there displayed. Thence I turned south to Ranital, Jawalamukhi and Dera Gopipur, crossing thereby a descending scale of damage similar, but in reversed order, to the ascending scale between Pathankot and Dharmsala. I next returned to Kangra, and thence journeyed E. N. E. to Palampur, which I used as a centre for traversing in various directions. From there I proceeded to Mandi *viâ* Baijnath, Dhelu, Guma, Jhatingri, Urla, and Drang. From Mandi I went to Kataula, thence crossed the Dulchi pass into the Lower Himalaya of the Kulu Valley at Bajaura, and traversed up the valley of the Beas to Sultanpur. Thence with a party organised by the Assistant Commissioner, Mr. Calvert, into the higher valleys of the Parbati river, first over the Borso pass to Channi, Jari and Manikarn, and thence returning *viâ* Rashole, Malana and Naggar. From Naggar I returned down the Kulu valley to Larji, visiting the enormous landslips and dammed-up valleys of that part. Thence to Manglaur and Jibhi, and thence over the Jalori pass to Kot, Chawai, Dalash, and Luri in the

Sutlej valley. From Luri I travelled *viâ* Kotgarh and Narkanda to Simla where I brought my tour in the Lower Himalayan region to a close on 15th June. During it I had covered along the line of march alone, a distance of about 365 miles: I had traversed the epicentral area along its whole length and also radially in five main directions.

Personal observations follow the line of route taken.

The record now to follow of observations of the earthquake phenomena and effects in the Kangra-Kulu epicentral tract will be grouped mainly in the order in which I visited the localities. For all the direct observations I am alone responsible. For all other sources of information, the name of the contributor, or the name and date of the newspaper or other authority will be quoted. As damage to buildings will form one of the most important phases of earthquake effects herein noted, I give the following scale of terms (increasing downwards) as used by me in describing damage of varying intensity:—

Scale of terms applied to house damage.

1. Cracked. }
2. Rent. } Roof and walls still standing.
3. Fissured. }
4. Ruined. Roof gone, many walls standing.
5. Destroyed. Only portions of walls standing.
6. Levelled with the ground. Nothing left standing.

Pathankot (Gurdaspur District).

I spent one evening, 12th April, at this place which is the railway terminus for the Lahore-Pathankot branch of the N. W. Ry. Except for the throng of relief and reconstruction parties moving up to the front, one would have been unaware that a destructive earthquake had passed over it only a week ago. I possess two earthquake-forms relating to this locality which are here summarised:—

Earthquake Form.—J. G. Skene, Lt., 7th Gurkha Rifles, was standing with feet apart in the road facing the railway station. Time 6-10 by watch compared with railway time shortly afterwards. One shock, motion at first slight, then increased and then subsided. It was like a ship rolling. Hanging lamps in station swung lengthwise with the station. No sounds particularly noticed. No damage, only plaster fell from arch of station.

Earthquake Form.—Telegraph and post master. Time 6-9, time compared with Lahore every day at 4 P. M. There were first, vibrations E.—W. judged by hanging lamp. Secondly, main shocks. A cracking noise [probably rafters of house].[1] No damage.

(See also account of the Bari Doab canal near Pathankot, p. 314.)

My own observations showed that the railway station had no visible cracks. The line was completely undamaged. The travellers' bungalow and houses in the bazar uninjured, so far as a cursory inspection could say although many of them were of a most unsubstantial kind.

Nurpur (Kangra District).

From Pathankot to Nurpur the road follows along gravel and alluvial flats of the Chakki river and does not touch rock until close to Nurpur. No visible damage was detected on the way.[2] Nurpur itself stands on the crest of a normal fold in the younger Tertiary Siwalik conglomerate. Strike N. W.—S. E., steep limb of fold to S. W. At the travellers' bungalow, built of local stone, there were just visible cracks at the joints of the walls. Nothing had fallen, including new mud plaster which had recently been applied to the doorways. The bungalow khitmatghar said the house rocked " this way and that," indicating a *slow oscillatory* motion and not a quick jerky motion.

Shahpur (Kangra District).

First violent effects of the earthquake.

From Nurpur to Shahpur the road follows generally along the strike of the folded Siwalik conglomerate and the underlying Nahan sandstones. Between these places the first violent effects of the earthquake were noticed at Siapari, 34 miles from Pathankot. Shops at road side, roughly built of sun-dried bricks and with heavy slate roofs, partly ruined. Similar effects at 37 m. 7 f., at 38 m. 1 f. and at 38 m. 6 f. At Shahpur itself, 39 m. 5 f., there were also similar effects: perhaps half of the buildings ruined and the rest rent. All were built of sun-dried bricks, roughly shaped, and sometimes with stone foundations raised 6 inches above ground. Slate roofs as a rule, but sometimes thatch. (See plate 3, fig. 2, which illustrates the end house of a row

1 Remarks in square brackets [ ] are my own comments.
2 I was travelling rapidly by *tonga*=mail cart.

fallen.) The travellers' bungalow had been badly rent. It was a single-storied building and had a dressed-stone base and corner verandah pillars. The walls were partly stone (dressed) and brick, set in mud mortar. The two chimneys had fallen and crumbled irregularly. The slate roof, of rather low pitch on iron rafter frame. and pillars running round verandah had not suffered much. The end walls facing N. W. 5° N. and S. E. 5° S., just did not collapse. Cracks everywhere, and completely irregular, appearing through the plaster like the course of a river on a map. There were no clean-cut fractures.

Country round Shahpur.

Beyond Shahpur, in the directions of Dharmsala and Kangra, ruined and destroyed villages and hamlets were everywhere in evidence. Most of these, including Shahpur itself, are situated on the flat expanses of what is the beginning of the Kangra valley, a broad nearly level area among the Siwalik and Nahan rocks. These expanses consist of very thick sub-recent accumulations of gravel, sand, alluvium and large granite boulders which begin as talus fans with a slope of about 1 in 10, continue over large areas with a slope of about 1 in 20, and finally mingle with one another in a nearly horizontal deposit. They are everywhere cut through by the present river and stream systems, making river cliffs of varying heights. Except for the large boulders, which owe their origin to the proximity of the high Dhauladhar range, the sub-recent deposits of the Kangra valley resemble those of other sub-Himalayan longitudinal valleys, such as the Dehra Dun, Patli Dun, etc.; and their heterogeneous character and lack of cohesion as deposits must have greatly augmented the destructive action of the earthquake; as also must the circumstance that they are cut up into long raised blocks or strips running N. E.—S. W., and only a mile or two wide, by the deeply scouring action of the rivers and streams of the present day. Thus free edges in the shape of river cliffs from 50 to 200 feet high are everywhere not far away.

Geological structure.

Destruction on elevated sub-recent plateaux.

Crops and trees undamaged.

In contrast to the ruined villages there was no damage to the crops or trees which presented simply an ordinary appearance.

Rehlu (Kangra District).

Damage to village.

The village of Rehlu, 2 miles N. E. of Shahpur, is situated at the head of a gently sloping debris fan, like those described in the last paragraph, of sub-recent clay and with boulders of Dhauladhar gneissose granite of great size and in great profusion. It is probably largely redistributed moraine material which originated in the higher snowy ridge of the Dhauladhar, rising steeply to the north. The damage to houses here was about equal to that at Shahpur. Twenty-eight persons are said to have perished in the ruins.

Damage to fort.

The fort stands on an isolated ridge above Rehlu village and 200—300 feet above the latter. (See plate 2, fig. 1.) Its site also is composed of remade morainic material, *i.e.*, clay and large boulders of granite, all derived from the snowy range above. The hill behind Rehlu Fort is composed of Nahan sandstone and Siwalik conglomerate, and there are cracks in the steep hill-side running about N. W.—S. E. above the fort. These, I think, are only surface cracks, there being no evidence of anything but motion with gravity. The fort is a massive structure, standing four-square with corner octagonal towers.

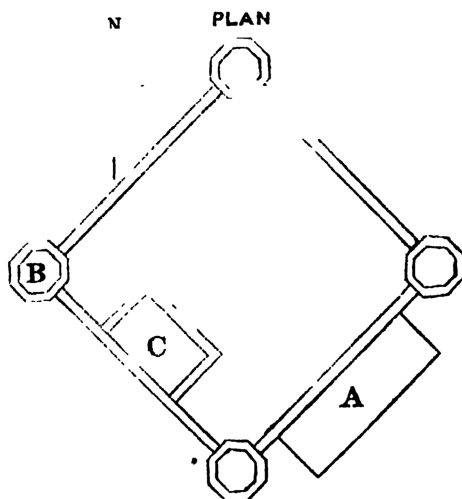


Fig. 1.

A great part of the N., E, and S. towers had fallen. Also the house where the Rajah Azimulla Khan with one uncle, five cousins and twenty-eight retainers perished, A. The tower B still stood, but was badly fissured. C = high keep, not fallen. The N. E. wall of the fort showed a horizontal crack (which also passed through the towers) coinciding with the lowest shooting platform above where the wall was thinner and loopholed.

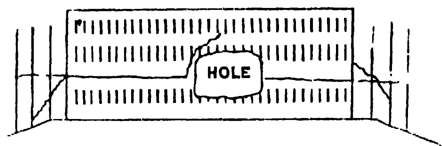


Fig. 2.—Elevation of N. E. wall.

In the centre of this wall a great hole had been made. The wall just failed to rock over to the north-east.

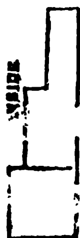


Fig. 3.—Section of N. E. wall.

Route between Shahpur and Dharmsala.

Intense damage sets in.

This line of country showed intense damage to the villages, hamlets and lines of communication. The cart road, 2 miles S. E. of Shahpur, showed small falls of steep cliffs by the side of a stream-bed. Nerti village, 3 miles from Shahpur, was nearly all destroyed. All the upper stories had gone and most of the lower as well. At three and a half miles from Shahpur, where the road branches off from the Kangra road and turns up the Khad

Chambi (winding under cliffs of talus and remade morainic material with alluvium, sometimes as much as 150—200 ft. high), the road was broken away at many places All, however, were at steep points of the road and the destruction was not more than might have occurred during heavy rains. About ¾ mile up stream the most recent alluvium in the bed of the valley was rent by little fissures running N. by E.—S. by W. Further up stream more and more frequent falls from the gravel banks were found at intervals of every hundred yards or so.

Road and cliff falls.

The hamlets, Dhanotu and Dudhamb, were very badly wrecked, having a worse appearance than Nerti. At Chari we reached nearly the maximum of effect, the whole village being destroyed with the exception of one or two stronger buildings (*e.g.*, the school) which were half ruined. Generally speaking the houses had become mere heaps of sun-dried bricks mingled with slates and rafters. (See plate 3, fig. 1.) Gharoh, which was only observed from a distance, appeared not so severely affected as Chari.

Dhanotu, Dudhamb, Chari.

During this journey I noticed the immunity enjoyed by the little water-mills built by the banks of the streams of rounded rubble stone and mud mortar. No more unstable structures could be imagined than these low cabins. Their position in the very bottom of the boulder-strewn valleys seems to have had something to do with their preservation from destruction, as also with that of the heavy iron girder bridge 3½ miles from Shahpur, built by Burn & Co. of Howrah, which remained undamaged. In other large earthquakes such positions have by no means enjoyed immunity; although the absence of much alluvium and the presence of loose rounded boulders may have made a difference in this case, the loose boulders serving (just as they do in Japanese foundations) to neutralise the shock.[1]

Immunity from damage in actual river-beds.

[1] *The Pioneer* of 26th April states:—"From Pathankot to Dharmsala there are hundreds of bridges, large and small, and only one was wrecked—within 2 miles of the Kotwali bazar—some with fine stone arches and others with iron girders all remaining intact."

Hill-spurs of Siwalik and Nahan rocks.

So far my route had taken me entirely across the sub-recent accumulations of the Kangra Valley. I next passed from these on to the highly dipping formations of the Siwalik and Nahan groups, as exposed in the hill-spurs running S. W. from Dharmsala Cantt. in the direction of Chari. At the head of the stream running due south to Gharoh, the strike in vertical Siwalik comglomerate is N. W. by N. following the general trend of the mountain mass. With the conglomerate are pale orange and greenish white sands and sandy shales. On the narrow ridge near 3,862 ft. point I noticed a vertical fissure in these rocks. About ½ mile beyond that point the path (mule track) climbs steeply up towards Dharmsala Cantt. over firmer and darker sandstone (Nahan sandstone). More fissures running W. N. W.—E. S. E. occurred in these rocks on steep places not far below the lowest cantonment bazar near the 5,287 ft. level. Near these fissures on steep slopes I noticed some of the trees in a slightly leaning condition (the lean being downhill), but much of this may possibly be ascribed to slow soil-cap movement—a common effect noticed on Himalayan slopes.

Rock fissures and leaning trees.

Dharmsala.

District head-quarters and sanitarium.

This hill-station, being the permanent head-quarters[1] of the Kangra District and summer head-quarters of the officials of the Jullunder District, having also a Gurkha regiment permanently located there, and generally containing besides many other residents, either temporary or permanent, was consequently a place of considerable size and importance. Very fortunately the summer visitors to these hills had as yet hardly begun to arrive. It possessed the usual offices, barracks, public buildings, private dwellings and bazars such as are ordinarily found in our Indian hill-stations and sanitaria. The earthquake therefore found here an abundance of buildings to destroy and a crowded population who suffered with their lives. The damage was in fact very severe, amounting in many places to destruction whilst

Severe destruction and loss of life.

[1] Removed to Nurpur after the earthquake.

the casualties reached a very high figure. Nevertheless, there were many cases of immunity to damage, or "earthquake shadows," which are of considerable interest. The greater part of the hill-station takes the form of a horse-shoe shaped ridge with the opening facing S. S. W. which together with other similar ridges and spurs, in the neighbourhood constitute the southern lower outworks of the precipitously rising Dhauladhar range behind. The two free ends of the horse-shoe slope down to the low country whilst the middle portion is the more elevated and rises on one side into the Dharmkot hill, about 7,000 ft. high, which connects with the higher snowy range. The westerly arm of the horse-shoe is mostly cantonment, and the easterly, civil; whilst private residences are dotted about at intervals. The whole of the station, both civil and military, is situated on rather soft tertiary sandstone of Nahan age steeply dipping to the N. E. The damage on the free ends of the spurs of the horse-shoe was much greater as a whole than on the higher middle portion near Dharmkot and the higher parts of the Civil hill.

Orography and geology of the station.

It was doubtless due to the great pressure of relief work in all its forms, falling as it did also on a civil and military staff reduced by about one-half by death, that the independent evidence as furnished by the earthquake-forms is almost *nil* from Dharmsala, as also from other places near the focus of the earthquake. The newspaper accounts also relate very few actual experiences of survivors, they being mainly concerned in their lengthy reports with the death roll, lists of wounded, exhumations, medical, telegraphic and postal arrangements, and descriptions of the campaign carried on by the relieving bodies of all kinds. The fact that the earthquake took place so early in the morning when most people were in bed or at least indoors, also tended to reduce the number of narrative accounts.

Paucity of local reports.

Dharmsala Cantonment.

Taking first the cantonment part of the station situated, on the western spur of the horse-shoe, we have, however, the following imperfect narratives as to the sensations and immediate effects of the shock or shocks.

Accounts of the shock.

Earthquake Form.—Capt. C. Stansfeld, 7th Gurkha Rifles, was in the house known as "Subalterns' quarters" belonging to the 1st Gurkha Rifles. He was indoors lying down in bed. Time about 6-15 (guessed). Two tremulous vibrations and two principal shocks, with about 3-4 seconds between the latter. The first shocks woke him, and he thought it was only a slight earthquake until he heard the roar which he diagnosed as the rumble of an earthquake shock, such as he had frequently heard in Shillong, Assam. It was this that made him leave the house. The shocks were so intense that as he got out of his quarters, he was thrown to the ground and at the same time the house, consisting of four officers' quarters, absolutely "sat down" without any preliminary swaying after the first shocks. The roar appeared to approach from the north-east or north. He was thrown down from N. W. to S. E. or W. to E.

Verbal corroboration of the above was obtained from several other officers. The experiences of Major Clay, 7th Gurkha Rifles, are instructive. He was living in "Woodside" (see p. 21), and whilst rescuing his little son was struck down insensible by a block of stone and partially buried under the debris from the chimney and wall. The continuation of the narrative is given in the words of the *Pioneer* correspondent, and they are quoted nearly in full as giving a vivid picture of the suddenness of the earthquake and the necessity for prompt action in cases of this kind to save the stunned and bruised from being suffocated:—

When Major Clay recovered from the shock, which rendered him insensible, he made for the quarter-guard some distance above his house. The guard had "fallen in," quietly awaiting orders. The assembly was sounded and all uninjured men appeared, and working parties were instantly formed under such officers as were unhurt. Most fortunately Major Hehir [Medical Officer], was among these, though one out of two hospital assistants was injured, and the other was suffering from shock. Both the latter, however, asked to share in the task before them. It had been seen that the European barracks [occupied by the 7th Gurkha Rifles] were wrecked, and Major Clay hurried there, disregarding his own injuries. The sight that met the rescue party was appalling. Some six or seven men were lying on the ground outside, and these seemed to be all the survivors out of over 250 known to have been quartered within the two buildings. In spite of overhanging walls and buildings, which threatened to fall every moment, the officers and men set to work, and their efforts were well rewarded. It is calculated that over 100 men inside the barracks were killed at once, while others who were dragged out of the ruins died shortly afterwards; but many injured would have perished had not their comrades toiled to the point of exhaustion. It was a fight against time, and everyone felt this. Men who were dragged out insensible and half suffocated no sooner recovered their strength than they rushed back to the ruins and joined in the work of rescue. It is believed that at the time of the earthquake many

were just getting ready to go out. They must have rushed towards the doors and been thrown back by the shock, and then been buried as the walls and roofs fell in. There is scarcely any case of men being found killed on their beds.

As many of the 7th Gurkhas were in the 1897 earthquake in Assam, they had had experience of what a great earthquake shock was like.

According to Subadar Khial Sing Gurung (who gave me the following evidence in the presence of Major Hatch, 2nd Battalion, 1st Gurkha Rifles) and who was an eye-witness of the earthquake, standing at the time on the magazine spur, —

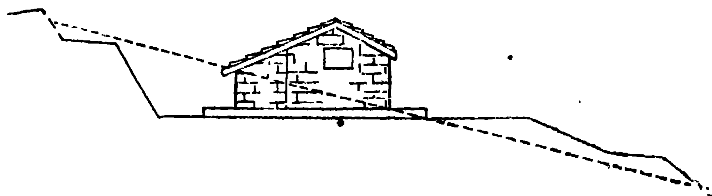
there was a certain order observed in the effects of the shock on the surrounding buildings and bazars. He said the old British Barracks and the 1st Gurkha mess fell first and practically together. These were followed by McLeodganj bazar and then by the Kotwali bazar (both on the Civil hill opposite). Next fell the bazar at the S. W. end of the Cantonment spur, and lastly in the far distance he saw Kangra in a dust cloud.

That the shock which upset houses and bazars could be followed by the eye has independent testimony, and seems quite credible, but it should not be forgotten that the above order very nearly coincides with his range of vision as it would sweep round from left to right. Furthermore in the case of distant positions, the dust cloud, started by falling mud-built dwellings, would take some few seconds to ascend and materialise in sufficient volume to be visible from the position he was occupying.

The following notes are based on my own observations :—

Gurkha lines, 2nd Battalion, 1st Gurkha Rifles.

The barracks occupied by the 2nd Battalion, 1st Gurkhas, were situated on the S. E. slopes and side spurs of the main cantonment spur, and not far from the crest of the latter. They consisted of long, single-storied buildings, the principal walls being built of sun-dried bricks, and the two end walls of cut stone. They were roofed with thick slates. They were arranged on slightly excavated sites as shown in the diagram (fig. 4.)



[?]G. 4 —End wall and slope.

which presented a cut face of soft rock behind and above, and a remade bank or terrace with retaining wall in front and below. The long axes of the buildings varied considerably in direction, but prevailing directions were N.—S. and N. E.—S. W., with the downward slope towards the E. and S. E., respectively. In all cases the two long walls had rocked over generally as a whole, in the downhill direction, with the exception of the portions immediately connected with the stone-built end walls, which latter stood (fig. 5). The heavy slate roof naturally collapsed with

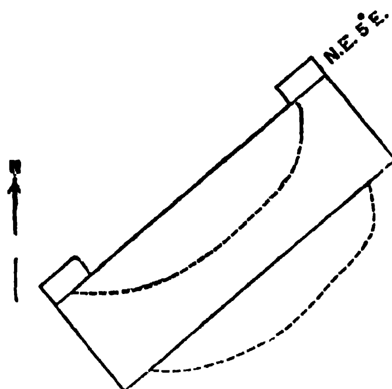


FIG. 5.—The dotted lines indicate fallen walls.

the walls. All the sun-dried bricks lay approximately in position on the ground, but each separated from its fellows by the shock of the fall.

Buildings in the immediate neighbourhood, such as the Armoury, built throughout of dressed stone, were badly cracked and rent, and portions, *e.g.*, a gable end, had been flung out as a whole flat on to the ground. The iron-framed roof, and with tie-rods across from wall to wall, doubtless materially preserved the Armoury, etc., from complete collapse. On the other hand, a few sun-dried brick buildings with stone ends wherever there was not a steep slope below had also not fallen.

The single men's quarters S. W. of the upper parade ground, and on the W. or N.W. slopes of the main cantonment ridge all fell as regards the long walls on the down-hill side and lost their roofs, whilst the walls on the up-hill side remained standing. The style of building is the same

Gurkha lines S. W. of upper parade ground.

as before noted in the barracks to the S. of cantonment, namely, of sun-dried bricks as regards the long walls and with end walls of cut stone. Their general direction was N. E.—S. W.

Magazine.

The Magazine stands on an isolated little knoll at the S. W. end of the cantonment ridge, and consists of a central square room very strongly built of well dressed stone and lime mortar. It possesses a strong and heavy arched masonry roof. The whole is surrounded at a few yards distance by a well built stone enclosure wall. The enclosure wall all fell more or less, whilst the building itself was undamaged save for a few cracks.

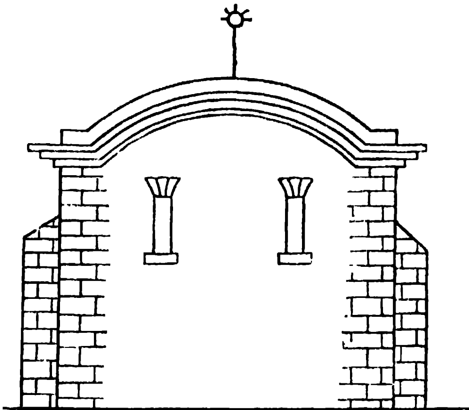


Fig. 6.—Magazine elevation.

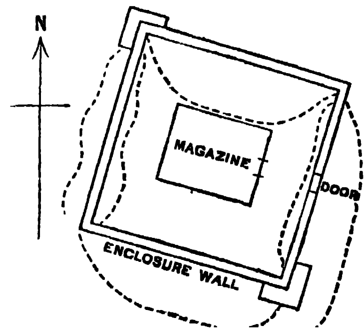


Fig. 7.—Plan of Magazine and enclosure.

The enclosure wall facing S. by W. fell outwards quite flat, the wall facing E. by S. also fell outwards but rather inclined to the south, a little of the debris being inside. The N. by E. wall fell inwards as a whole. The W. by N. wall fell irregularly partly inwards and partly outwards. This seems to give a general direction of shock about S. S. E. or S. Although the magazine was intact I was informed that the ammunition boxes inside were found tossed about.

It is clear that the heavy arched roof and the great strength and compact nature of the building preserved it from destruction.

Quarter Guard.

The Quarter Guard of 7th Gurkhas, a solid stone building with domed roof, also showed no damage, being of similar construction to the magazine. (Compare also the Treasury, and also the Sadr Kanungo's office and record-room on the civil hill which stand untouched. All were small and strong buildings without slate roofs.)

Old British barracks.

This large double-storied building was solidly built of dressed stone. It had a position on the crest of the ridge. Its destruction by the earthquake was almost complete. The photograph (pl. 4, fig. 1) will give a fair idea of the ruins which, however, at the time of my visit had been considerably disturbed by digging parties. The long walls parallel to the ridge had almost entirely fallen, but many of the cross walls were standing as regards the lower storey. All the latter were traversed by diagonal fissures crossing one another and illustrating the violent rocking motion that must have been set up in the building as the free end of the ridge quivered under the shock.

Officers' mess house.

Like the old British barracks, the officers' mess house was a double-storied building, solidly constructed and situated on the crest of the ridge below the British barracks. It was generally a complete ruin, although some walls and one or two upper rooms remained with their floors in position. The wine godown, a small domed detached building, was undamaged.

Other buildings, quarters and private houses.

Many other buildings, private houses and quarters in the neighbourhood were more or less demolished, with the exception of that occupied by Major Clay. They were described as crashing to the ground in a few seconds.

Casualty list.

The severity of the shock as experienced in Dharmsala Cantonments may be gauged by the heavy casualty list of officers and men and their families.

Of the 1st Gurkha Rifles all were present except the 1st Battalion. Its place was taken by the 7th Gurkha Rifles from Kohima on whom the greatest losses fell.

There were :—

Killed	..	272 (184 rank and file).
Dangerously injured	..	32 (31 ditto).
Severely injured	..	70 (54 ditto).
Slightly injured	..	261 (188 ditto).
Total Casualties		635

The following proportions among officers and their families is instructive :—

Killed	14
Buried and rescued	8
Escaped	12

Lieut-Col. and Mrs. Cowley were fortunately not present at the time, only returning on the evening of 4th. Lieutenant Skene was also absent. They are not included in the above figures.

Woodside.

Of private houses "Woodside" presented the most remarkable instance of immunity from the worst effects of the shock. Lying a little below the tennis courts it was surrounded on several sides by higher spurs and ridges where the destruction to buildings was either total or very extreme. As in the case of other examples of immunity or "earthquake shadows" that will be mentioned, it lay in a slight hollow or on a flattish slope on the S. E. aspect of the Cantonment hill. Its position thus was a favourable one, and to that was added the advantage of good building with good material (cut stone and lime mortar) and the fact that it was only one storey high. In this house whose long walls run N. 3° E. the worst effect was the fall of a chimney and part of the middle wall. There were of course also wall fissures, the prominent ones dipping E. at about 50°. With the exception of these, the house presented to the eye an almost undamaged appearance, heightened by the fact that of the large panes of glass 1 foot 6 inches by 2 feet in the windows, not a single one was broken. This last fact, strange as it may seem, is paralleled by others in Dharmsala, *e.g.*, Sessions House, Civil Hill (see p. 29).

1st Gurkha married quarters.

Due north of the upper parade ground (recently enlarged and a the time of my visit—18th April 1905—converted into a vast hospital camp) lies the 1st Gurkha Rifles mar-

ried men's quarters, consisting of about 16 ranges of buildings running lengthwise from N. N. E.—S. S. W. to N.—S., and situated on the N. W. or N. N. W. slopes of the cantonment ridge (fairly gentle slopes lying in a slight bay with a stream-bed running W. S. W. to Kajlot). The buildings are of the same nature as the ruined ones already described; but in this case there was scarcely any apparent damage. All the walls were standing and all the roofs intact. In one range 8 windows of four panes each had not a single pane broken. This may be regarded as another instance of earthquake shadow.

Immediately below the magazine to the E. in a little bay on rather flat ground lie more lines of barracks (married quarters) They also escaped although they lie only about 200 yards away from the destroyed bazar. (See pl. 7, fig. 2.)

Dharmsala Churchyard.

The churchyard is situated near the head of the glen dividing the Cantonment from the Civil Hill. There is a steep slope of nearly 45° to the south of the churchyard for a depth of 200—300 feet. Consequently its position near the free surface of a steep slope rendered it particularly unstable from the point of view of the earthquake.

Nevertheless most of the tombstones, including several upstanding vertical crosses[1] and headstones, remained unaffected by the earthquake. One, however, was twisted on its base, and one, the large, lofty and complex structure erected to the memory of the Earl of Elgin in 1863, had all of the upper parts fallen whilst the lower part was shattered. Of the gate-posts one was twisted on its base, similarly to the tombstone mentioned above, whilst the church itself, a solidly built structure of cut and dressed stone, was ruined. (See pl. 4, fig. 2.)

Twisted monument.

The tombstone of white marble, consisting of a cross on a pedestal, erected to the memory of Capt. M. H. Burne, Royal Sussex Regiment, had been twisted round on its base. The base lay E. 4° S. The twisted pedestal lay E. 7° N. so

[1] It has been suggested that some of these may have been supported by an iron rod within.

that the total angle through which the cross and pedestal have moved is 11°, the direction of movement being contrary to the hands of a watch. (See pl. 8, fig. 1, and fig. 8 below.)

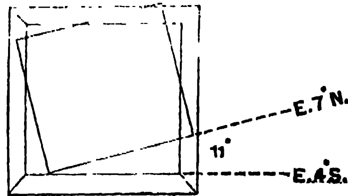


FIG. 8.—Plan.

Entrance gate pillars.

The gate pillars at the W. entrance are about 10 feet high. One of these was twisted on its base through an angle of 11° in the opposite direction to the hands of a watch just as in the case of the tombstone. (Figs. 9 and 10.)

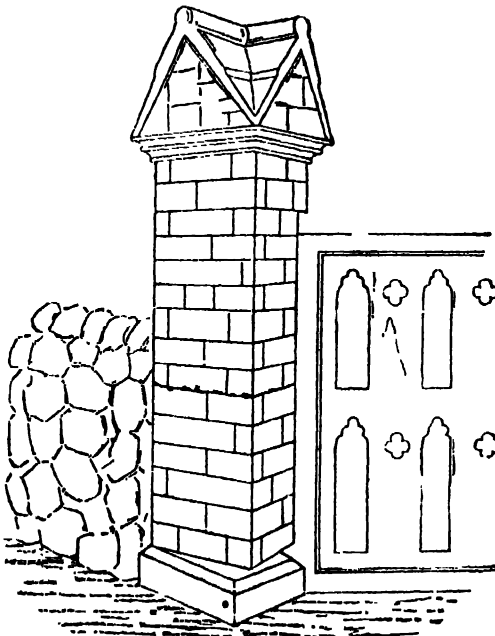


FIG. 9.

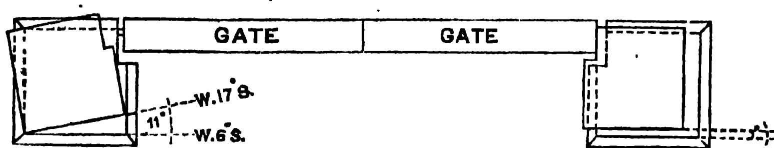
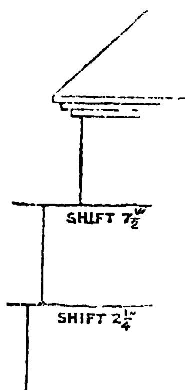


FIG. 10.—Plan.

Also about ½ way up the pillar from the base there was a horizontal crack and a similar twisting movement just begun. The other gate pillar had gone 1 foot or so in the other direction and been pushed eastwards (there was, however, a decided lean of the pillar as a whole in that direction). The gate posts at the east entrance were simply horizontally cracked along the corners with no decided movement.

Lord Elgin's Tomb.

The three horizontal courses of stone making up the body of Lord Elgin's tomb had shifted differentially, generally towards N. W. indicating a thrust of the shock from N. W.—S. E. On the S. face and on the E. face the amount of the shift was as follows:—



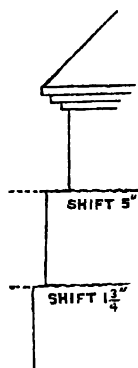


FIG. 11.—S. face. FIG. 12.—E. face.

These two resolved amounts of shift indicate a true direction of total shift of N. 36 W.

The fall of the superstructure of slender pillars and cross appears to have been somewhat irregular —

1	pillar	fell	nearly	N.
1	„	„	„	E.
1	„	„	„	S. E.
1	„	„	„	W. S. W.

The cross itself fell about S. E. by S. All the debris, however, was much mixed up with that from the E. end of the church.

The three-stepped stone platform of the tomb was fissured in N. and S. lines both on the W. and E. sides, whilst on the S. side the middle step had parted from the one below. The whole platform some 12 feet across, seemed to have been buckled under a bending strain. It was quite near to the edge of the ravine.

Dharmsala Church.

The church, a solidly built structure of good dressed stone and lime mortar, lies due E.—W. It is a complete ruin, such walls as remain partially standing being fissured, so that entire rebuilding will be necessary. The view (pl. 10, fig. 1) showing the church before the shock,[1] and that of the ruin (pl. 4, fig. 2) will give an idea of the general effect of the shock. The tower at the W. end had scattered its debris all round the base but chiefly towards the south, where also the greatest breaking down had occurred to the S. wall, whereas the N. wall up to the eaves, though fissured was still standing at the time of my visit (16th April 1905), twelve days after the earthquake.

The heavy stone cross from the top of the east end of the church had fallen almost due S. (2 feet further east). Its horizontal projection was 37½ feet, its vertical distance about 32 feet. The former was directly measured with a tape, the latter was an estimate formed from the approximate number (77) of the courses of stone of about 5 inches each. In the latter estimate the uppermost 10 or so courses had to be guessed as they were not left in position. It will be noticed that the greatest damage on the S. side of the church corresponds to

[1] I am indebted to Mrs. Ballard of Palampur for this view.

the direction of the free edge of the steep slope below the churchyard already mentioned. The tower and east end wall were fissured diagonally like the walls of the British barracks, showing strains due to rocking about its long axis, and drag of the falling long walls.

Bazar, S. W. end of Cantonment.

The bazar at the S. W. end of the cantonment ridge was a complete ruin, but not utterly destroyed. Many walls were still standing especially those (see pl. 5, fig. 1) on the upper side of the slope.

Forsythganj bazar.

Forsythganj bazar lies about N.—S., the S. end beginning in a little bay along the E. slopes of the cantonment ridge. It consists of a double row of shops with the road dividing them, the buildings being constructed in the usual way, partly of sun-dried bricks especially in the lower stories and partly of wood especially in the upper stories and verandahs. Heavy slate roofs with a low pitch were everywhere apparent (see pl. 7, fig. 1). The view is taken from the south, and it shows the N. end of the bazar all down, at the S. end also the shops on the E. side of the road are all in ruins, whereas those on the W. side of the road are many of them still standing. The site especially at the N. end of the bazar was a bad one on slipping surface debris of Nahan sandstones and shales; that to the E. of the road had a bad slope down hill, whilst only where the shops stood which were preserved from the earthquake was the site good. It seems to have been another case of an earthquake shadow occurring in the angle of the little bay already referred to.

Dharmsala Civil Hill.

Whilst some few private residences on the higher slopes, *e.g.*, "Welcome Hall," have not utterly collapsed, though rent, fissured and half ruined—as was also the case with some few houses on the higher slopes of the cantonment hill—McLeodganj bazar half-way down the spur, the very large Kotwali bazar at the S. and lowest end of the spur, and most of the surrounding private residences were perhaps more completely destroyed than anything on the cantonment hill. The mortality also seems to have been somewhat greater in proportion, and

the accounts of those saved show a shade less time for escape between the beginning of the earthquake and the fall of houses.

Accounts of the shock.

We have the following accounts of the shock and its attendant phenomena derived from local sources. A native correspondent in the *Pioneer* of 11th April wrote :—

The vast majority of residents were abed at the time and got crushed in the ruins. The houses lurched forward with violence and came down as if they were made of cards, those left standing collapsing with the back movement.

Rescue and exhumation went on during the day under Rajindar Pal, the only Magistrate left alive.

At night the scene was weird in the extreme. The wretched and grief-stricken survivors huddled themselves together in the open near the dâk bungalow, made piles of timber extracted from the debris and set fire to them to keep away the cold, while at some distance from them the dead lay burning on funeral pyres. Every second or third hour there was a shock, although not very severe and a roar like the boom of cannon.

An eyewitness states in the *Englishman* of 15th April—

The morning was calm and beautiful, and then in a moment with *two fearful* lurches every house collapsed amid the thunder of falling rocks, roar of the falling rafters and walls and the thousand shrieks for mercy, confusion and terror and death.

Mrs. Loxton's bearer related :—Our houses fell down. With difficulty we managed to get to the sahib's house only to find it fallen. The sahib in rushing out had been thrown back into a corner and was killed, and we could hear the memashib calling. Being guided by her voice, and after digging for what seemed like hours with our hands, for we had nothing else to dig with, we found her kneeling by her bed with stones and rubbish on her back, her head was cut and bleeding and her face and body much bruised. Her leg was broken. We wrapped her up in blankets and took her up to friends.

In the *Pioneer* of 19th April, the Dharmsala correspondent wrote referring to this part of the station :—

It seems to be generally admitted by the survivors that a slight preliminary tremor was felt, followed by a sharp shock from north to south, with a still severer one in the opposite direction. There was a rumbling sound, which added to the terror inspired by the violent rocking of the ground. Mr. Longe, Assistant Engineer, was writing at a table in his bedroom placed against a door leading into a larger room when he first felt the earthquake. * * * * * He with his wife and two children escaped through the window amidst falling masonry and beams, and in clouds of dust.

Mr. Williams, engineer to the local board, with his wife and two daughters had an extraordinary escape. He made several vain efforts to open the door

of the room in which he was standing, but the rocking of the house was so great that he could hardly stand. He got out at last into the passage to find his wife and daughters practically imprisoned in another room, the door of which was also difficult to open. They also reached the passage and the whole party rushed under an arch as the final crash came. They saw one main wall fall outwards, thus opening out an avenue of escape across the debris. They reached the open air uninjured, though suffering from shock. The whole affair was a question of seconds and the arch undoubtedly saved them, as the house was wrecked.

The *Englishman* of 10th April has the following from Lahore:—

The experience of Mr. Homan, one of the survivors, is probably characteristic of them all; he felt a shock and rushed for the door; he had only just reached the doorway when the roof of a room fell in. At the same instant his two children, sleeping in an adjoining room, were killed by the fall of the roof. His wife and baby had a marvellous escape, a great beam from the ceiling fell slantwise across the cot on which the baby was sleeping; Mrs. Homan having rushed from her own bed to protect the baby when the first shock awakened her.

Thus also the *Pioneer* of 10th April:—

A native barrister, who has arrived in Lahore from Dharmsala, reports that the only building he observed intact was the domed strong room of the Treasury. This survivor had a narrow escape. His house came down before he had time to get out, but fortunately by the position in which a beam fell saved him from instant death. His cries for help were heard by two servants, and he was extricated uninjured. He borrowed some money and in his torn clothes walked to Shahpur, where he got an ekka to take him to Pathankot.

Earthquake Form.—Nadir Nowrojee Khujooria of McLeodganj bazar wrote that he was indoors on the 3rd floor facing the road, sitting at an office table writing. Time 6-10 by clock found afterwards stopped. The time is telegraph time. There were three shocks. Tremulous vibrations, like the rustling of leaves of trees preceded the 2nd shock. The interval between the shocks was a little over a minute. The direction of the shocks from goods which were hanging on the walls was first E.—W. The second shock collapsed the walls. No sound was heard before, but a shrill high note as if something was passing through the leaves of trees preceded the second shock. He noticed the upheaval of foundation stones and no side pressure. Parapet walls, etc., seemed twisted by some strong power.

My own observations of the ruins are as follows:—

McLeodganj bazar.

McLeodganj bazar is situated on a very narrow portion of the Civil ridge forming a low saddle. The slopes descend very steeply on each side. The whole bazar was levelled to the ground with no buildings standing, even partially (see pl. 5, fig. 2). Messrs. Framjee & Co.'s shop, a high building perched on the west face of the ridge, had also utterly collapsed, as also

had the Switzer Hotel a short way further south. The devastation was so intense in this bazar, and the confusion of building material so complete that beyond the fact that the collapse was as perfect as could be, there is nothing more to be said.

Kotwali bazar.

The same remarks apply to the very large Kotwali bazar, situated low down on the Civil ridge, which was also completely levelled as regards the shops and native houses. The site of this immense bazar was not in fact merely a ruin but a thick deposit of house-rubbish some five feet high through which it had been necessary to cut out roads and lanes for rescue and salvage operations. Plate 6, fig. 1, will give some idea of the appearance of the eastern half of this convulsed jumble of what had once been a busy town.

Jail.

The jail site was badly fissured, and a drop of about 10 ft. took place along a line parallel to those made by subsidences of the ground during previous years which damaged the jail site and led to its being condemned (see pl. 6, fig. 2). This drop of 10 ft. had cut through buildings and water channels and also through what was the wall of the jail compound. The latter presented a curious appearance as it had become simply a rampart of loose blocks of stone. Both it and the subsidence cliff are seen in the photograph. Other minor subsidences and fissures extended along the slope towards the west.

The Sessions House.

The Sessions House, a heavy stone building, south of McLeodganj bazar, had a portion of the walls still standing. One window frame vertically projecting out of the debris had a large number of panes unbroken. The ridge is very narrow here.

Private dwellings.

The following private dwellings are only mentioned as being illustrative and not exhaustive. The first, situated on the higher and broader part of the Civil Hill overlooking Bagsu Nath temple, is north of McLeodganj bazar. The other three are all south of that place :—

"Welcome Lodge" was not an absolute ruin, but was severely fissured and partly destroyed.

"Cedar House," a double-storied building, beautifully situated among green lawns and deodar pines, had utterly collapsed, and was

simply a heap of stones with window frames and rafters projecting from the untouched debris.

"Mortimer Cottage," also a double-storied building near by, was in a very similar condition.

"Bryn" stood on a very steep-sided spur, and as a consequence not only was this solidly built, single-storied stone house ruined (see pl. 8, fig. 2), but there were also fissures in the ground 3—6 inches wide, opened lengthwise parallel to the crest of the ridge. There were as many as 20 or 30 of these on each side of the house.

Fissures in the hillsides.

As compared with other steeper hillsides, neither the Cantonment hill nor the Civil hill showed much in the way of earth fissures. Such fissures as appeared on the steeper ridge crests and the slopes on each side were frequently parallel to the present contour lines. On the crest of the Cantonment ridge in the steeper parts they consequently ran N. W.—S. E. especially above and below the parade ground, whereas along the cart road on the S. E. slopes of the higher parts of the same hill they ran N. E. and S. W.

From the Cantonment hill, the steep scarps north of Bhag Devi (about 5 miles W. N. W. of Dharmsala) could be seen to be interrupted by frequent large landslips.

Other prominent fissures on the Civil hill have been noticed in the previous descriptions.

Hillsides and villages N. and N. E. of Dharmsala.

Naddi village, situated on a spur N. W. of the Dal lake, and which is one of the offshoots of the Dharmkot hill, was only about half damaged. Travelling round the N. side of Dharmkot hill from this village one looks across a wide valley which descends westerly from the saddle uniting Dharmkot hill with the higher ridges beyond to the N. This valley and saddle roughly mark the line of that great structural feature of the whole Himalayan range known as the main boundary fault[1] which separates the Nahans and other younger tertiary rocks from the older Himalayan series composed of slates and limestones. Across the valley and about one mile away several hamlets with crowded houses were

[1] See Mem. G. S. of I., Vols. III, XXIV, pt. 2, and XXVI.

visible, perched on the hillsides which slope steeply to the S. Very little apparent damage had been caused to these, certainly much less than to Naddi. The walls and roofs were standing as a rule. In a hamlet of 8 houses I could only see one house half damaged; its upper storey having collapsed. That hamlet is N. by E. of Naddi. Others N. and N. N. W. of Naddi were equally undamaged.

As these villages are quite close to the actual main boundary fault, it seems certain, even if we had no other evidence, that the shock did not originate actually along that feature just here. Beyond these hamlets further N. the ridge rises steeply and becomes forest-covered, with snow lying here and there. There were no more villages visible in this direction. But near the saddle already mentioned joining Dharmkot and the higher ridges, and a short way to the N. of the main-boundary fault, there were hamlets of from 4—5 houses which showed no damage or scarcely any. In the Dharmkot group of hamlets lying in the valley running S. E. from the gap the same remarks hold good for the greater part of the little group, but towards the S. E. end in the lower parts of the valley some damage was discernible.

Bagsu Nath temple, N. E. of the Civil hill in the valley descending from Dharmkot, was apparently undamaged. Also the slate quarry bungalow near it, and many hamlets further up the valley showed only 1 house in 8 somewhat damaged.

Kangra Town.

Because the direct road from Dharmsala to Kangra was interrupted by numerous slips not yet reparied, it was necessary for rapid travelling by tonga to return to Chari and to the Khad Chambi, and from there continue along the main road from Pathankot to Kangra, where it follows a very nearly straight course along the wide and open Kangra Valley. This road was broken at many places, especially wherever it makes a V-shaped curve up-stream under gravel cliffs at each river crossing. A raised embankment of earth and stones leading to the bridge at one of these crossings was also shaken to pieces, leaving only a narrow

Road between Dharmsala and Kangra.

knife-edge, difficult even for pedestrians. No bridges, however, were broken. Near Kangra a few boughs of trees in the long avenue were occasionally found detached, but only in the case of those already weakened by decay. There were no examples of tree trunks having been snapped across as in the Assam earthquake of 1897. Nevertheless every village without exception was destroyed, and appeared as a mere rubbish heap disfiguring the landscape.

Kangra Bhawan.

Kangra Bhawan lies at the southern edge of the gravel and alluvial plain, just where the Siwalik conglomerate and associated sand-rock and shales emerge from under it, dipping gently at about 10° to the north-east. Further south again stretches old Kangra and the Fort, the former situated on a gravel terrace and the latter on a narrow neck of rock. Just below this is the meeting place of two main streams draining the country north and east. They run in deep gorges cut through rock and gravels, and present innumerable free cliff surfaces, several hundred feet high, which must have been a most potent factor in magnifying the earthquake effects.

No earthquake-forms have reached me from Kangra, owing to the deaths of officials. The following account, extracted from the *Pioneer* of 20th April, gives a vivid picture of the destruction wrought in the town :—

Looking up from the camping ground to the low and beautifully wooded hill upon which the town and temples stood, one could not see any sign of buildings, but among the trees there was a gleam of yellow light reflected from the roof of the Kangra Bhawan or Golden Temple.[1] On the ridge still higher some heaps of masonry showed where Mr. Seiston's house and the missionary buildings were lying wrecked; and following the road to the town one came within a hundred yards of significant signs of devastation. Immediately on the right was all that remained of the Municipal Dispensary, and near by on the same side was the Thana, with the Treasury buildings on the left. The last two had been solidly built with cut stone walls, and heavy beams and roofs. They had been literally shivered and the masonry disintegrated An old masonry bridge had been broken up. It was little larger than a culvert, and was the first I had seen broken from Shahpur to Kangra. Following the road leading to the temple we had evidence on every hand of the earthquake. Not a house was standing, and

[1] Correctly known as the temple of Bajresari or Vágreswari Devi.

the flatness of the ruins was terribly impressive. Passing among the ruins we came out above the wreckage of the great temple itself. A confused mass of masonry lay below. The thick walls were rent, small shrines broken up and only one miniature temple (*sikra*) left, and even this had been partly thrown down, and was standing tilted over at a sharp angle. The golden roof and cupola were resting on the ruins, some of the gilded metal plates having been broken off by the shock, but the roof as a whole not having lost its distinctive shape (see frontispiece). The thickness of the walls was enormous, as the temple was most strongly built, and yet the masonry was shattered as if the structure had been weakly constructed. Below the temple we saw masses of ruins. These marked the site of the houses used for the reception of pilgrims and they have yet to yield up their dead. Those who perished there must have died instantaneously, for the debris is even now an almost impenetrable mass. The very height of these houses caused their fall to be appalling. Treasure and jewels, worth several lakhs of rupees, are said to be under the temple ruins, and the recovery of these will be attempted later. For the Kangra Bhawan was a most sacred place, pilgrims from even distant Southern India coming to visit it. Ranjit Singh once came to the temple, it is said; while long before, 900 years ago, its riches attracted Mahmud of Ghazni, who plundered Nazarkote, as it was then called, carrying away the great idol and an immense store of treasure.

From the site of the temple we passed upwards, still climbing among the trees until the broad paved way led us past the Amritsar Mission School houses and playground. The buildings were well constructed of stone, but were now mere piles of debris. Then the crest of the hill was reached. Here lay the smaller temple of Devi utterly wrecked and the remains of the Mission Church with its bell lying among the shattered masonry. The church and temple had stood side by side and their ruins were mingled. Lower down on the crest was the Mission House where the Rev. Mr. Rowlands, Mrs. Decauble and Miss Lorbeer were killed. One can see the verandah where the two ladies were sitting at the time the earthquake occurred, and the suddenness of the shock is proved by the fact that they were unable to escape. Here on the crest can be seen long narrow fissures running east and west (see pl. 1, fig. 2). Big branches have been broken from the banian and peepul trees, while the cactus plants also show signs of damage. Following the fissures upwards we found that they became more marked at the highest point of the ridge, where the Sessions House stood on a small plateau, but they were never more than four or five inches in width. The soil, too, is rather loose, so they may not extend to any depth. The Sessions House was a large stone building commanding a magnificent view all over the Kangra Valley. It was completely destroyed, being almost instantaneously shaken from its foundations and crumbling to pieces. One need not refer again to the lives lost here, for the story is too pitiful.

South-west, on the lower spur, Kangra fort lies utterly wrecked. It stood in an isolated position overlooking the slope to the north-east on which were a cluster of houses of old Kangra. These lie wrecked almost hidden amongst the

trees. Great landslips have occurred along the road which winds down the hill-side totally obliterating the track in some parts while other slips threaten, for these low hills about Kangra are made up of clay, rounded boulders and conglomerate rocks easily displaced, and heavy rain would bring down masses of earth and trees.

Such is the scene now presented at Kangra, but one's imagination cannot picture the horrors of the actual calamity on the morning of the earthquake and those which followed before help arrived. There was no one left alive who could direct operations for rescuing the people buried in the ruins or succouring those who had been maimed and were yet alive. All the subordinate officials were killed. No European was within reach and the people fled panic-stricken fearing that yet worse terrors would envelope them.

My own observations generally corroborate the above, and I am able to add a few more details especially with reference to overthrown objects. The following description, which appeared in my preliminary account, may advantageously be reproduced here.

Overthrown objects.

The old European cemetery at Kangra Bhawan lies in the middle of a flat plain, and at the time of my visit exposed a number of rectangular masonry pillars, overturned or broken with more regularity of direction than I have seen elsewhere (see fig. 13). They comprise:—

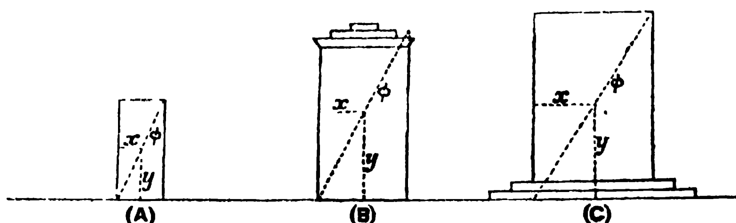


FIG. 13.

(A) Two small, rectangular upright tombs, 3 ft. high, by $1\frac{1}{6}$ ft. square. Fallen as a whole towards N. E.

(B) A pair of gate-pillars, of dressed stone and lime-mortar outside, with rubble within, 5 ft. high by $2\frac{1}{12}$ ft. square. Fallen as a whole, one towards E. 25° N. and one towards W. 20° S. (*i.e.*, nearly in opposite directions).

(C) A pair of piller-like tombs, constructed like the gate-pillars, $5\frac{1}{2}$ ft. high by $3\frac{1}{3}$ ft. square. Not upset as a whole, but shattered above the base into fragments.

Using West's simplified formula for determining the acceleration of the wave particle, a formula which has stood the test of much experimental proof, we have :—

$$f = g\frac{x}{y}$$

where x = half diameter of the base and y = the height of the centre of gravity.

Then, in the three cases above, we have as follows :—

For (A) f = greater than	$11\frac{2}{3}$	ft.	per sec.	per sec.
For (B) f = about	13	,,	,,	,,
For (C) f = less than	19	,,	,,	,,

Since in the case of (A) both bodies were upset towards the direction of shock, and in the case of (B) one towards and one away from that direction, whilst in the case of (C) they were not upset at all, we may deduce a rate certainly between $11\frac{2}{3}$ and 19, and probably near 13 ft. per sec. per sec. for the acceleration of the wave particle at Kangra.

But, according to Prof. Omori, the formula :—

$$2a = \frac{4x\,(x^2 + y^2)}{3y^2}$$

where $2a$ is the double amplitude or range of motion of the overturning edge, will yield a limiting value for the amplitude of the earth vibrations in the case of short periods where the pillar is overturned towards the direction of impulse. Using it we obtain the result,

$$a = 9\tfrac{3}{4}\text{ inches,}$$

an amplitude which is large, but not excessive in the case of soft ground near the epicentre of a great earthquake.

Seismological Journ. of Japan, Vol. XVIII, p. 120 (1893).

Using this value for a in the general formula:—

$$f = \frac{4\pi^2 a}{t^2} = \frac{v^2}{a}$$

where t is the period of the wave and v the maximum velocity of the earth particle, we can obtain values of t and v. We thus have altogether:—

Acceleration	$f =$	13 ft. per sec. per sec.
Amplitude	$a =$	$9\frac{3}{4}$ inches.
Velocity	$v =$	$3\frac{1}{4}$ ft. per second.
Period	$t =$	$1\frac{4}{7}$ seconds.

On the other hand, by using Prof. Omori's second formula for the case of a pillar overturned in the forward direction when the period of motion is comparatively long, and applying it to the second of the pair of gate-pillars overturned away from the direction of shock, we get:—

$$v = \sqrt{\frac{8gy\,(1 - \cos\phi)}{3\cos\phi}}$$

where ϕ is the angle between a vertical side and the diagonal of the pillar. That is:—

$$v = 3{\cdot}87 \text{ ft. per second,}$$

a value which is sufficiently near the one previously obtained by the other method to be corroborative of it.

In the same cemetery also a large flat slab, 4 ft. 10 in. by 2 ft. and 4 in. thick had moved 4 in. towards N. 60° E. (Fig. 14.)

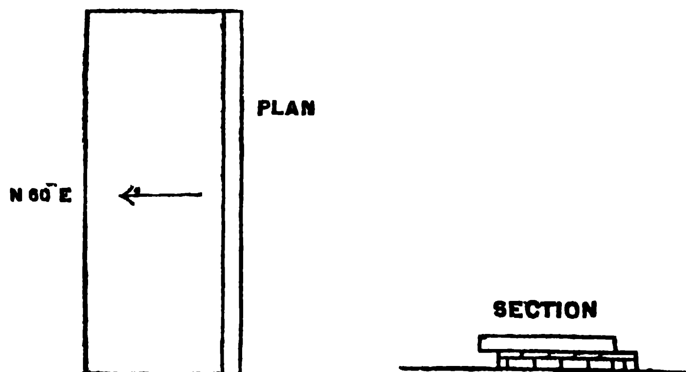


Fig. 14.

A pair of Suttee pillars, about 6 ft. by 3½ ft. near the cemetery had fallen E. by N. They were situated on a little ridge, but fell diagonally to its length and to cracks in the ridge. There were also a number of other little temples and shrines generally in the form of simple *sikras* like that depicted in pl. 2, fig. 2, which have been tipped up at an angle, shifted horizontally, or otherwise moved. The following vertical section (after Fergusson) of a typical *sikra*, or stumpy convex spire belonging to early Hindu temple art, will show the general nature of such rather stable and well built structures. They are always erected over idols or other representations of the deity and are very numerous in Kangra and the valley parts of Kulu. They are about 15 to 20 ft. high. (Fig. 15.)

Suttee Pillars. Temples and *Sikras*.

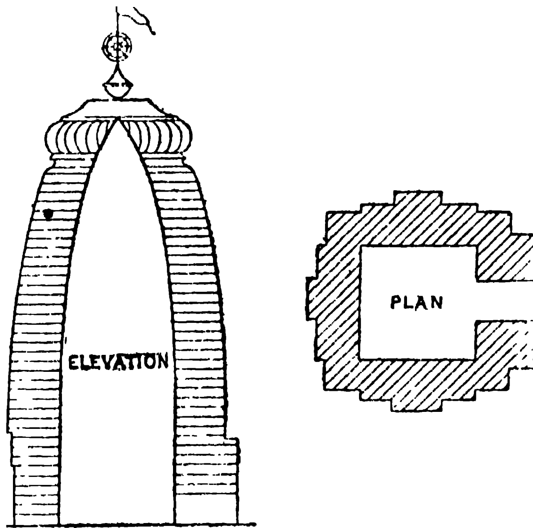


Fig. 15.

The old cemetery near the N. E. gate of the fort had suffered but little damage. The walls and tombs were standing as a rule. One cross had snapped, but the pieces had been picked up and put aside by the gardener. Other square upright

Kangra fort cemetery.

tombs had horizontal cracks. One flat slab of stone had shifted ¼ inch towards E. 3° S with a trace of twisting.

Roads; Bridge.

The roads in the neighbourhood of Kangra wherever they pass along the edge of a river-bed, and especially when they pass up the main river-beds under cliffs of sub-recent gravel or of Siwalik conglomerate, had been much broken away; and at the time of my visit (24th April) were only just becoming passable for small vehicles. The large iron girder bridge with stone piers, which crosses the river just below old Kangra, and is elevated 40 ft. above the river, had only suffered damage to the towers which rise from the piers. These had generally fallen towards the east.

Route from Kangra to Dera Gopipur.

This journey was made in two stages, and whilst at Dera Gopipur I visited Jawalamukhi returning the same day. The country lies in the heart of the Siwalik formation and is characterised by long parallel ranges of conglomerate, sand-rock and shales, striking N. W.—S. E., and with long dip-slopes facing N. E. and scarps facing S. W. as a rule, the angle of dip increasing from 10° to 40°. This traverse well illustrated the rapid dying-out of the effects of the earthquake in this direction, for when Dera Gopipur was reached all visible signs of damage to buildings had ceased. Within this small radial distance we descend through the 10, 9 and 8 isoseismals.

Daulatpur.

Daulatpur, the first considerable village met with on the way, differed in no material respects from Kangra itself. The bazar had been completely destroyed, and the main road traversing it had to be re-cut through the debris. This and a Devi shrine, a simple *sikra* rolled over on its side, are well depicted in the view (see pl. 2, fig. 2). As regards the latter the heavy and solid superstructure had doubtless crushed the foundations before it toppled over into the road.

Two large lopped trees within a few miles of Daulatpur had fallen, one S. 12° W. and the other N. W. They had scarcely any roots and were probably in a dying condition.

Ranital bazar.

The few houses constituting the bazar at Ranital, lying in a line, had suffered at both ends of the row. The post office and another shop had collapsed. The pilgrims' rest-house and other long ranges of buildings below the bazar had their slate roofs twisted and buckled, and the same is true of others roofed with thatch. Otherwise they were comparatively uninjured. The travellers' bungalow was badly rent, and portions of the upper walls had fallen. This damage was partly influenced by the steep little hill on which the bungalow is perched, and partly by the fact that although the building is of cut stone, mud mortar had been used inside the walls, only their outer face being pointed with lime mortar.

It will be seen that the intensity of the earthquake, as represented by house damage, declined with extreme rapidity between Daulatpur and Ranital. Whilst the former place resembled Kangra, the latter was the equivalent of Shahpur in this respect.

Dera Gopipur.

On the way to Dera Gopipur the first-half of the journey of 14 miles still showed considerable damage to the numerous hamlets, walls having fallen away or huge fissures appeared in them here and there. During the second-half of the distance where there was not so much slate roofing, and where tiles of light construction and thatch roofs began to be common there was but little damage. Tiles had fallen and been replaced, and there were some good cracks. Beyond this point at Paisa, and thence to Dera Gopipur there was no visible damage. A close scrutiny of the travellers' bungalow at the latter place showed merely a few minute cracks in corners, etc., where the whitewash had parted. Although the postmaster described the shock as having been of extreme severity here, the undamaged and of course habitable bungalow, and the ordinary every-day appearance of the pretty little town showed that it must, as regards intensity of the shock, be ranked with Nurpur.

The Mangra tower, an old military post some miles away on the western of the two routes to Ranital, was visited by me on my return journey. It is situated on a steep ridge and had portions of the central octagonal tower crumbled away irregularly, whilst the

whole of this lofty, old and heavy structure was seamed with old and new vertical cracks, all more evident at the summit of the walls.

Jawalamukhi.

Jawalamukhi lies east of Dera Gopipur and at the base of and on the slopes of the scarp rising about 2,000 ft. above the valley which runs N. W. to Ranital. The damage done is chiefly to the part of the town resting on the slopes (see pl. 11, fig. 2) and is about equal to that at Ranital and Shahpur. The celebrated temple had not suffered much, and the inflammable gas given off by the springs in the latter, I was told, had not been affected. But it was universally admitted that the water flowing down the ravine from springs had been doubled in volume. A large bell of bronze, weighing more than 18 maunds (of 40 seers) had fallen W. S. W. On the way to Jawalamukhi from Dera the damage made itself apparent by gradual stages, but there was very little serious damage until the slopes of the hill were reached.

Route from Kangra to Palampur.

This route, as far as Malan, passes along the flat Kangra Valley, composed as before of sub-recent gravels, etc. It then runs S. E. for a few miles between two ridges of Siwalik sandstone and then along the flat valley deposits to Palampur. The villages on the way, including Nagrota and Malan, were nearly equal to Kangra in point of destruction. Two stone bridges across the streams between Kangra and Nagrota were broken, and diversions and new bridges had been constructed. The Malan bridge, a stone arch, was intact, but the raised approach to it was shaken to pieces.

Palampur.

The pretty little town of Palampur with its surrounding Tea Estates suffered grievously from the earthquake. Its site on a long N.—S. terrace of sub-recent gravels stretching from the foot of the higher mountain range out into the plains, and with a steep cliff on the west leading to the bed of the Maul Khad resembled that of the Kotwali bazar, and doubtless caused a local magnification of the surface effects.

A few accounts have come to hand from Palampur. Captain McKechnie, I.M.S., is reported as estimating that about 100 lives were lost at Palampur and 10—20 per cent. in the surrounding villages.

A letter from Mr. Millar, I.C.S., which appeared in most of the newspapers, described his narrow escape. He was staying in the travellers' bungalow with the Raja of Mandi:—

He was awakened by bricks and plaster falling on his head and ribs. He took refuge under the bed and then the roof fell in. He was pinned down by the bed which broke, but his servant hearing his cries came in and extricated him. They then went and got the Raja out of his room. The latter was buried under bricks and timber and had a marvellous escape as the whole place fell 5 minutes after getting him out.

Mr. F. Ballard's son was similarly buried, but for a considerable period of time, and Dr. Owen had to use artificial respiration for an hour.

Earthquake Form.— Mr. A. N. Macbean of Clachnacuddin Tea Estate reported three shocks, the second longer and more violent than the first, and from the north-east or east. The third seemed a sudden jerk from north-east and back again. He himself had a narrow escape, being protected by a window of a wall which did not fall.

Bazar and public buildings.

My own observations showed that the bazar and station had suffered not quite so severely as lower Dharmsala and Kangra (see pl. 9, fig. 2). There were the relics of several houses standing, also the post office, which was still partly in use. But the other public buildings, such as the court-house, sessions house, school and church, were total ruins, though portions of the walls still stood. A number of small crosses in the church-yard were standing uninjured as at Dharamsala, only one flat slab having been slightly moved.

The Church.

The church (see pl. 10, figs. 2 and 3) [1] had the arches on the north side of the central aisle all down, whilst those of the south side were standing. The west end of the church (which had only a small bell-tower) was much broken, and the east end remained as depicted in pl. 10, fig. 3. It should be noted that the steep cliff down into the Maul Khad was in the near

1 I am also indebted to Mrs Ballard for the photograph of this church before the shock.

proximity of the west end of the church. The heavy stone cross from the summit of the east gable-end of the chancel was found on the ground to the south a horizontal distance of 27 feet 4 inches from its original position. The pedestal of the same was 4 feet away to the north-east of the cross. The indentation on the ground made by the falling cross was, however, only 21 feet 10 inches horizontally from its original position. The original height of the cross in place was 37 feet 1 inch as determined with an Abney's level. The pedestal of another cross from the east gable-end of the nave was found on the ground to the north 22° E., the horizontal distance being 24 feet 3 inches. The height from which it came can only be guessed from the appearance of the photograph of the church before the earthquake. It was about 46 feet. Both the pedestals can be detected in the photograph.

Tea Factories.

The tea factories near Palampur were ruined, most of the walls and roof being down and the machinery buried and considerably damaged.

Landslips and dust cloud, Neogal Gorge.

One of the most striking local effects of the earthquake as witnessed near Palampur, was the column of black dust which appeared ascending from the precipitous slopes of the Dhauladhar range at the head of the Neogal Gorge. On the 28th and 29th April, some days before my visit to Palampur and whilst at Kangra, I had noticed the above-mentioned dark grey cloud ascending rather like smoke from the ravines below. The appearance lasted for several hours, but was most distinct between 10 and 11 A. M. The snow of the ridges near could be seen to be covered, and almost black with the fallen particles. On arriving at Palampur I found there was a certain amount of disquietude among the inhabitants as to what the cloud might portend. With the assistance of Mr. Ballard who knew the locality and also along with Captain McKechnie, I.M.S., I visited the Neogal Gorge and penetrated as near to the scene of the phenomenon as we could get. This took us well among the older slates and quartzites of the higher range. From the summit of a side spur 4 or 5 miles N. N. E. of Palampur, marked 8,256 ft. on the 2 inch = 1 mile map, and about 3,500 feet above the bed of the gorge

we could see and watch clearly the scarred surface of the rock from which the puffs of dust arose at intervals (fig. 16). It was evidently a

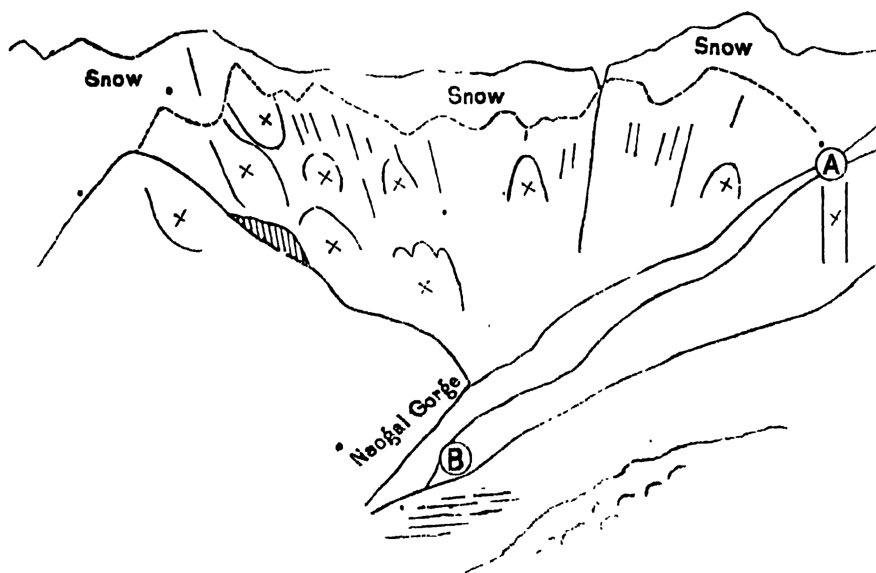


Fig. 16.

Chief slips marked (X).

A—B 8,256 ft. spur.

steep precipice among the older rocks at the head of the gorge due N. of our position, many thousands of feet high on which landslips and fissures, originally started by the earthquake, were still in action, helped by the melting of snow along the top. Whenever a more than usually large slice of hillside collapsed it was followed by a gigantic puff of dust simulating volcanic action (See pl. 9, fig. 1.) In spite of the size and activity of this slipping area, it did not warrant the belief said to be common among the natives that the range as a whole had moved and settled down at a lower elevation. In addition to the prominent slip just referred to, the eye could detect minor slips all round, whilst the soil-cap of the small and narrow ridge on which we stood was exceedingly rent and fissured in E.-W. lines. Furthermore

the intervening slopes and spurs, including that marked 8,961 on the 2 inch=1 mile maps, were so much shattered by the earthquake that we could not have advanced further in the direction of the dust cloud even if we had had time. In the lower parts of the gorge the numerous falls of the western edge of the gravel plateau near Sahan had carried away with them long sections of the water channels which supplied the fields below. These at the time of my visit were being repaired by the "Pioneers." During my stay at Palampur there were several slight aftershocks felt there, each one being accompanied by a fresh shower of material from the surface of the landslip.

Bhawarna

The town of Bhawarna, 6 miles S. S. W. of Palampur, was almost a complete ruin like Palampur itself. All the upper stories and most of the lower stories were gone. One or two mostly wood-built shops with wooden pillars supporting the verandahs did not fall, but evidently swayed with and so escaped, the shock. A small Hindu temple had not fallen a a whole, but the top circular amalaka stone had fallen S. W.

Route from Palampur to Mandi.

This route followed generally along the northern and eastern limits of the low-lying sub-Himalayan tract and skirting the foot of the higher ranges.

Holta Tea Estate.

On the Holta Tea Estate, a short distance from Palampur on the way to Baijnath, seven bungalows were ruined or thrown down. The damage varied in degree, but was not so great as at Dharmsala. Mr. Ballard's house, a well-built, double-storied structure of stone, had portions still standing, the lower storey generally, and the upper storey in parts. The standing part was very severely fissured and ruined. The factory, situated on a bit of rising ground between two streams, had suffered still more.

At Banuri the damage had mostly been repaired, but the shops and houses appeared to have been about half destroyed. Paprola had mostly fallen.

Baijnath.

Baijnath had not suffered so much as Paprola, although the two towns were only separated by a river. Many wood-fronted shops still stood, and a newly built, three-storied house of sun-dried brick (see pl. 11, fig. 1). There were a few falls of canopies and cornices from the temple buildings, mostly in a direction S. by W. The travellers' bungalow was worse damaged than at Shahpur and not so much as that at Ranital.

Earthquake Form.—Mul Rajpuri, Sub-Postmaster of Baijnath, noted the time as 6-15 by a pocket watch compared at 4 P.M. with Madras time telegraphed from Amritsar. No tremulous vibrations before. Great shock lasted 3 to 5 seconds. Direction W. to E. by movements of houses. Many landslips of river cliffs. Road bridge broken. All houses and shops levelled to the ground. [This is a gross exaggeration, see pl. 11, fig. 1.]

Mr. FitzGerald's houses.

South of Baijnath Mr. FitzGerald's houses suffered considerably, but his tea-factory escaped, and numerous hamlets round about were still standing.

Earthquake Form.—Mr. FitzGerald noticed a tremulous motion, increasing in intensity, until he was nearly thrown off his feet. There were no distinct shocks, all appeared one huge vibration. The ground appeared to be moving in waves. Trees swayed with terrific force to within a few feet of the ground. Puffs of dust marking villages falling, progressed from south to north. Birds rose with deafening shrieks, and a dog and cat ran away terrified. The sound was a terrific roar as if a gale was approaching from the south, 5 seconds before the shock began.

On the whole it may be stated that the plain of the Kangra Valley between Palampur and Baijnath marks a diminution in the visible effects of the earthquake shock, but this diminution is not rapid, and as we shall see further on, the intensity characteristic of this locality continues unabated for long distances into Mandi and Kulu.

Road from Baijna to Dhelu.

But about 1¼ miles S. E. of Baijnath in a little bay in the Nahan Sandstone ridge up which the road goes there was the village of Ghartoli, which so far as I could see was quite intact. Slate and thatch roofs alike were standing. Also 2 miles E. S. E. of Baijnath there were a few shops on the northern dip-slopes of the Nahan Sandstone ridge which were similarly unaffected visibly. At the same time in the valley to the north between that ridge and the main mountain range there was considerable ruin

to the villages which could be seen to be half down. They were situated on alluvium. The same contrast was noticeable 5 miles before reaching Dhelu.

At Dhelu the travellers' bungalow was standing though the chimney had fallen.

Between Dhelu and Guma the road approaches the main boundary fault lying near the S. W. foot of a distinctive and steep little continuous ridge striking N. W.—S. E. and finally closing up in this direction all that might structurally be considered as a part of the Kangra Valley. The villages and hamlets scattered along the way are built very roughly of irregular lumps of rock set in dried mud and with thatched roofs. About one-half of these cabins were down. About 2 miles from Dhelu, on the way, there were many cracks and fissures across the road. Near Guma many small landslips were seen scarring the hillsides in the vicinity of the main-boundary fault, especially where steep crags of limestone occur. At Guma itself the shops and houses are chiefly stone-built below, and with wooden superstructure. These were generally half ruined, and some had collapsed altogether.

Guma Salt Mines

At the Guma salt mines the salt-bearing pebbly and earthy layers strike W.N.W.—E.S.E. in a nearly vertical anticline outcropping beneath rocks consisting of epidiorites, amygdaloidal trap and white quartzite. The former, immediately associated with the salt, are brightly coloured a brick-red, pale purple, or greenish gray, and during the earthquake gave way in numerous slips, bringing down with them much of the rocks above. The rock-salt is said to continue as a bed from here to Drang, but obscured by talus and soil-cap.

Jhatingri.

Jhatingri lies on the crest of the little ridge alluded to in the last paragraph but one, at an elevation of about 6,000 ft.' The Rajah of Mundi uses it as a hill-station, and had just built a large bungalow there. It lay with its long axis

N. W.—S. E. that is, parallel to the ridge. The *chowkidar* said the shock came along the ridge, and not across it. Many of the walls were partly broken down, and the roof had been buckled somewhat. Being a strongly built, single-storied house, however, it had stood fairly well. The very ancient travellers' bungalow, badly built of fragments of undressed slate and mud mortar, was in ruins, and the outhouses partly down.

Country beyond to the east.

From the summit of this ridge we get a first glimpse into the mountainous area of the next geological zone, instead of the view being blocked (as happens N. of Dharmsala) by lofty ridges of gneissose granite forming the Dhauladhar range. We can see for many miles into a quite different style of country, the much sculptured, and broadly and deeply eroded older rock series of the Outer or Lower Himalaya of the Kulu Division. In this direction which takes one to the Bubu pass, the steep E. slopes of the Jhatingri ridge, composed of finely foliated mica schists, showed very few signs of landslips. The wooden bridge with stone piers at the bottom of the intervening valley was intact, and so appeared most of the villages as seen from this distance. The Bubu pass, however, was not as yet open to traffic. With a telescope it appeared to be blocked in the narrow summit defile by fallen masses of rocks.

As it was impossible to cross by the Bubu pass into Kulu, I returned from Jhatingri to the main road to Mandi, and made my first halt at Urla. On the way I noticed the prevalence of small landslips and soil-cap slips as the main-boundary fault was approached. The travellers' bungalow at Urla was in much the same state as that at Shahpur. It was built of rough stone slabs of slates. etc., fitted together without mortar or mud cement, and with wooden beams horizontally laid among the stones at intervals. This style of building is a debased form of the hill type of wood and stone buildings, so common in Kulu and other hilly parts of the Himalaya, and to which I shall have to refer to again later on. The chimney had fallen W.

N. W., either having been projected clear of, or slipped down, the roof, and then having crashed through the verandah. The shops in the village were not much damaged.

Earthquake Form.—A. Gardner, N. I. Salt Revenue Department, at Drang. No tremulous vibrations felt. Direction of the shock N. W.—S. E. by sensation. Three times he attempted to stand without success. Upper roof of Salt Department bungalow fell. Walls cracked. Large landslips on steep slopes of Salt Mines, completely blocking many of the workings. Sound like rushing water, about 1½ seconds before the main shock.

Drang Salt Mines.

Along the main-boundary fault between Uhl and Drang I noticed the presence of Siwalik conglomerate and sandrock for a considerable distance. At Drang the limestone on the inner (Himalayan) side of the fault was considerably brecciated. The salt mines at Drang are more extensive than those at Guma, but as they similarly consist of mere excavations in the bed of the ravines, exactly as they were when described by Mr. Medlicott[1] in 1864, it was natural that they should have been much damaged and filled up by landslips during and subsequent to the earthquake. The salt was, however, still being excavated at one place, but, owing to the treacherous nature of the very steep cliff of the peculiarly coloured sandy and earthy, rotten rock, or *salt-gossan*, which is barren of salt, and lies above the salt, it was necessary to keep a careful watch for cracks in order to warn the miners when to desist. The rocks here were generally the same as at Guma, but the salt, and the salt-gossan, above the former, were much thicker and about horizontal. It is curious that the salt beds should occur as the core of an anticlinal fold coincident with much crushing and brecciation (a condition which reminds one also of those obtaining in connection with the salt-bearing marl of the Salt Range), near the main-boundary fault, and, so far as actually known, only along the 14 miles between Guma and Drang, *i.e.*, just in the extreme angle made by the main-boundary fault as it changes its course in sweeping round the N.E. end of the

[1] Mem. G. S. of I., Vol. III, pt. 2, pp. 60—62.

Kangra Valley. Considering the way all the rocks of the Himalaya generally, especially near the main-boundary fault, have been packed up and slipped over each other by thrust planes, one can quite legitimately speculate on there being repetitions of the salt-bearing beds below the present surface. Whether such could in any way have been implicated in the chief or contributary conditions which determined the sudden snap or movement at great depths which caused the earthquake, is, however, a question one cannot very well discuss. It is noticeable that the salt-bearing area at the surface is very nearly centrally disposed across the middle of the Kangra-Kulu epicentral area.

Salt springs near Jawalamukhi, and in Kulu.

The presence of salt-bearing beds in other parts of the Kangra-Kulu epicentral area is indicated by saline springs, as for instance in the neighbourhood of Jawalamukhi, where such occur at intervals extending over some 30 miles. They are 6 in number and issue from the southern base of the range of hills known by the name of Jawalamukhi. They contain from 2·20 to 2·63 per cent. of mineral matter, chiefly common salt and iodide of potassium.[1] There are also saline springs situated 1 mile N. N. W. of Larji, and under Girauli trigonometrical station in Kulu. Of the latter Calvert says: [2] "further, near Barogi village the mountain is said to be all rock salt."

Mandi.

Mandi lies in the valley of the Beas R. at its junction with the Suketi Khad, not far from where the former emerging from its gorges in Kulu crosses the main-boundary fault and then turns north. The town is situated on a plateau of gravels, partially covering Nahan sandstone, which latter strikes N. and S. The plateau is elevated

[1] Gazetteer of Kangra District, Vol. I, pp. 22—24, quoting *Punjab Products.*
[2] Kulu, the Silver Country, by John Calvert.

about 50 ft. above the level of the Beas R. About 204 deaths occurred here.

Earthquake Form.—Sri Gopal, Vakil to the Mandi State. No tremulous vibrations. Three almost successive shocks. Direction N. W.—S. E. A booming noise preceded the shock.

Most buildings of the type of the travellers' bungalow, guest-house, school and post office, all one-storey high and stone-built, had not suffered much. Their walls were generally standing though much damaged, and the roofs also though buckled in places.

The Palace.

The palace, a lofty building, and very old in parts, had suffered by portions of the walls collapsing.

Of other buildings, all those with rounded water-worn boulders in the composition of their walls, had collapsed as a rule, sometimes wholly, and sometimes partially.

Temples.

The well-built stone *sikras* of temples near the river generally had not been damaged: but the *amalaka* of an old temple S. W. of Mandi had rolled down the surface of the dome in a N. E. by E direction. Another temple had its golden pinnacle upset according to report to the W. N. W., and afterwards stones fell the other way.

Tahsil.

The *tahsil*, a double-storied building, was badly cracked, and portions of the walls including the S. W. corner had fallen. It was, however, a top-heavy structure roofed with heavy Mandi slates, which are sometimes as much as $\frac{3}{4}$ to 1 inch in thickness.

Many houses of two and even three stories, with a solid stone base (often dressed stone) and with an entirely wooden upper storey; as well as many three-storied buildings made of wood and stone intermixed, the wood courses being at intervals of 4 to 5 ft. and bonded at the corners, stood the shock very well, especially if they were roofed with light slates.

Much of the relatively severe damage done to Mandi was due to the use of very heavy slates, and to the mixture of water-worn boulders in the walls.

Mr. Millar's house.

Mr. Millar's house, double-storied and lying approximately N. and S., that is, along the valley, had its end walls most damaged, especially at the S. W. and N. E. corners.

The suspension bridge at Mandi across the river, a fine structure built in 1877 by Rajah Bige Sen, was intact, and had not suffered more than a good shaking. The towers, however, rising 25 ft. high above the roadway, and 50 ft. above the river-level, were furnished with 4 flying turrets one at each corner, each finishing in a pinnacle. The top conical stones of these pinnacles had been shifted horizontally along the rest of the pinnacle without falling, in the manner shown in the sketch and plan below, which represents the northern tower. (Figs. 17 and 18.)

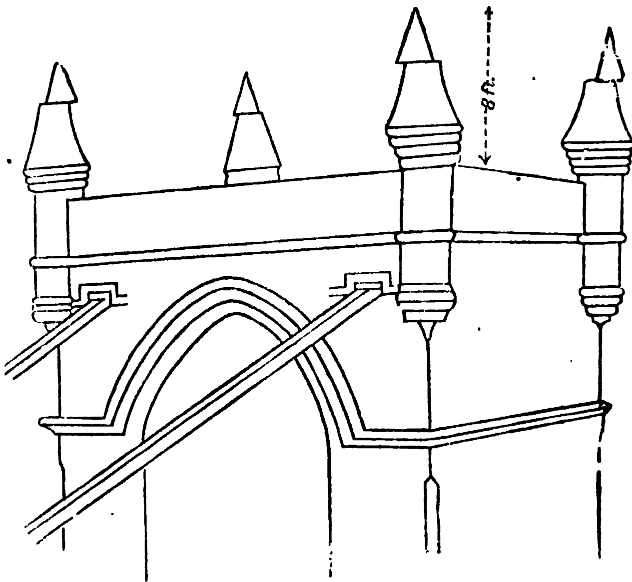


Fig. 17.—View from N. W.

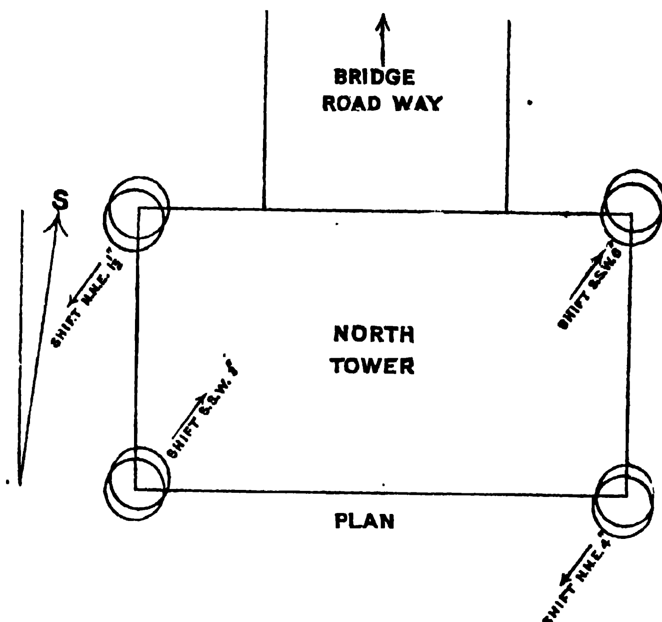


FIG. 18.

From the southern tower all the capping stones had fallen, except in the case of the S. E. turret where the top stone and lower courses had shifted opposite ways in a N. N. E.—S. S. W. direction. In the case of the N. E. turret 2 courses of masonry below the conical capping stone had also fallen.

A comparison of the nominal damage to this structure with the total destruction of the similar bridge at Buin in Kulu will illustrate the difference of the effects of the earthquake on good and bad buildings. The latter structure was largely built of rounded river boulders, the former of cut and dressed stone.

The general appearance of the town before [1] and after the shock is shown in plate 12, where it will be observed there is considerably less roof area visible in the second view.

[1] I am indebted to Mr. A. Gardner, Northern India Salt Revenue Department, for the photograph of the town before the shock.

There was considerable destruction wrought in Parli Mandi, on the north side of the Beas R.

Parli Mandi.

On the whole the evidence in Mandi shows a direction of overthrow of bodies about N. N. E.—S. S. W.

In Mandi State and also in that of Suket large numbers of cattle are reported to have been killed owing to the custom of placing them in the lowest stories of houses, the second storey being used for grain and the third for living quarters. (*Pioneer*, 14th April 1905.)

Route from Mandi to Bajaura.

The bridle-road to Kataula mounts first across the ridge which is the direct southern continuation of that at Jhatingri and above Drang. It, therefore, takes us across the main-boundary fault once more, and also across the great *melange* of torn and brecciated limestones, epidiorites, and quartzites which have been involved in the main-boundary movements; whilst the deep gorges seen to the north, in which are the villages Kalwana and Maigal, expose the salt rocks of Drang. Before the top of the ridge is reached schistose slates appear, and also form the eastern steep slopes down to the Ool R. and on to Kataula, with a small but distinct band of gneissose granite at Hulog.

Kataula.

We have now in fact left behind us altogether the younger zone of Sub-Himalayan Siwalik and Nahan rocks, and definitely penetrated into the heart of the older rock zones of the greater Himalaya. Gentle slopes and flowing ridges with cart-road communication are done with, and ridges, spurs and valleys are now on a more colossal scale, and with only bridle track communication.

The villages on the way showed considerable damage and many boulder-built huts were completely thrown down, there were a few small landslips.

The travellers' bungalow at Kataula, an old and badly built small structure made of slate fragments roughly fitted together, was destroyed with the exception of one corner.

Kandi.

The road to Kandi crosses the Dulchi pass, 6,740 ft. high, a very steep climb, especially near Kataula, where the route followed was a steep diversion on account of the regular bridle-road having fallen a few miles above Kataula. A hurricane, blowing at the time of my visit, almost necessitated crawling along some of the more exposed spurs. Just below the Dulchi pass, on the Kataula side, there was an extensive slip in fractured schistose slates which had carried away some mules a short while before. None of the slips here, however, were as bad as those near Guma, the schistose rocks holding together better than the jumble of rocks at the main boundary fault.

Earthquake Form. – Rev. Jas. Tunbridge, C.M.S., in Kandi travellers' bungalow. Main shock impelled him W. and E. Earth fissures ran mainly downhill, S. E. and N. W. Loud rumbling noises underground. Chimney fell in, and side-walls fell outwards [this seems to be an error, as the walls were standing at the time of my visit]. Fore-shock? About 4 A. M. a loose board rattled, which Mrs. Tunbridge declared to be an earthquake shock. Rocks from cliff opposite, N. side of the pass, fell in thousands of tons below, and continued to fall for hours afterwards.

My own observations showed the bungalow to lie with its length N. by E. and S. by W., the verandah looking down a steep slope towards W. by N. The bungalow was not more damaged than Shahpur. The cross walls were a little fractured and the plaster had fallen from them. Otherwise the bungalow was standing fairly well. The outhouses below to the W. N. W. had been much smashed and some of Mr. Tunbridge's servants were temporarily buried under them.

Bajaura.

Road from Kandi to Bajaura.

Between Kandi and Bajaura the same schistose rocks continue, and there was not much damage along the road until Ropru was reached. All the wooden bridges across small streams were intact. Ropru itself with its flat roofs was not seriously damaged. Report says that many cattle were killed, but only one human being. Landslips became more frequent at Ropru and on to Bajaura. They were not very large, but had partially blocked the road.

At Bajaura we are once more in the valley of the Beas river but in its higher reaches, having taken a short cut over passes instead of following its complicated windings. These upper reaches form the wide and very open valley of Kulu where also the Beas receives numerous tributaries. As a consequence it flows among sub-recent gravel and talus fan deposits of considerable thickness, and the slopes on all sides rise, some steeply and some gently, to enormous heights, although in its lower windings between this point and Mandi the river follows narrow defiles or profound gorges. Here and there the steeper crags and slopes were streaked by gullies filled with broken and powdered rock whose white and fresh appearance indicated that it was the result of the earthquake.

Earthquake Form.—Col. R. H. F. Rennick (Indian Army, retired). At Bajaura, Kulu Valley. Time 10 mins. to 6 A. M. [This is probably a slip for 6-10.] Duration fully 5 mins. At the first shock things fell W. It was of extreme violence resembling a bombardment. The ground quivered. Walls rocked to and fro N.—S. and E.—W. and danced up and down like a bubble of water on a hot plate. One could hardly walk. Several people were sent sprawling on all-fours. Doors of rooms jammed and then opened again. Pictures 36 in. by 30 in. hung by 6½ ft. wire from roof were flung out E. and then returned to wall, backs outwards. Large *almirahs* fell. A heavy upright (Brinsmead) piano fell against the wall. A heavy lamp 12 in. high and with a base of 6 in. fell W. Bowls, cups, glass and other objects were scattered all over the rooms. The sound was a dull rolling noise, which became a roar like a cannonade when the principal shock was felt. It began about 10 secs. before the shock. Also the roar of stones, chimney stacks falling, furniture, together with the underground noises was something abominable for about 5 minutes [probably too long]. Upper storey walls partially in ruins, Manager's house, fruit house, stables, mills, pigeon and grain houses badly shaken. Springs of water increased their discharge. Free-swinging objects swung E. and W. but N. and S. in Naggar. Fissures along the Beas river, and also across. Jets of water rose 4 to 6 ft. shooting out spray and sand. No sinking of ground except where ground was artificial. Fissures on hillsides at Naggar. Trees not uprooted except by falling boulders and in the case of those whose roots were rotten. Many villages crushed in like a box of matches. About 50 deaths on the estate.

Earthquake Form.—Lieut.-Genl. W. Osborn, at Bajaura during the earthquake. He had lived many years in the West Indies, where earthquakes are common. Time 6-10. Duration 1¼ mins. taken by watch. One single accelerating motion, until it reached its climax of greatest violence, where it remained for some few seconds and then died away as it had begun. He ran out of the house into the orchard at the first tremor. Direction S. and N. by movements of orchard trees.

He had to hold on to the branches of trees to steady himself when the earthquake was at its most violent point. He saw the chimney on the N. face of Col. Rennick's house fall due N. Flower-pots also fell over in that direction. Being rather deaf he does not offer any opinion on the sounds. Road from Bajaura to Naggar impassable. Had to ride along the alluvial bed of the river. Fissures there chiefly E. and W. Other fissures on slopes. At Naggar his house hardly damaged at all [probably by being protected by being in a bay of the hills and on solid rock.] A chief characteristic of many of the aftershocks, as contrasted with the big shock, was that they commenced with a strong vertical upward thrust, or push, followed by a gentle horizontal vibration.

Colonel Rennick's house and other buildings.

Through the kindness of Colonel Rennick I was able to examine his house and other buildings. The former was situated on the high plateau part of the valley deposits formed of sub-recent gravels, which as already mentioned are very extensive along the course of the Beas river. The house is a solidly built double-storied structure made of selected flat slabs of rock. Its upper storey was damaged, but not severely. The guest-house, which lay with its long axis N. W. by N. had suffered as to its end walls of the upper storey, but the side walls were standing. A solidly built stone dove-cot had been turned through an angle of 5° in a direction with the hands of a watch. Its lower part was shaken to pieces, but its upper part, supported on timbers from below, had stood. It had been repaired as it stood without taking down, and with the twist remaining in it. Servants' houses, bazar, and the surrounding hamlets showed varying damage, but mostly severe. Wherever houses had fallen it was apparent that the building material was chiefly round river boulders and mud mortar. Altogether the damage was about equal to that of Mandi.

Temple.

The Shiva temple at Bajaura, a very ancient well built *sikra* of cut stone, 800 to 900 years old, had been shifted a little laterally by many an ancient earthquake, as shown by the discontinuous sections of the doorway pilasters. It had suffered very slightly from the present earthquake. The priest showed me one fresh horizontal plane of separation only, high up on the lower part of the structure. The roughly built quarters round the temple were ruined,

as also was another wood and stone built Devtas' temple situated a little nearer the river.

Travellers' bungalow.

The travellers' bungalow was in a half ruined state. It was built partly of sun-dried bricks, and partly of flat blocks of schistose slate.

Route from Bajaura to Sultanpur.

Samsi.

Samsi village, near the Buin suspension bridge across the Beas river, was a great ruin. The suspension bridge was also destroyed, the piers on each side having crumbled away, and the wire ropes and foot-way having subsided into the swiftly-flowing stream. This collapse was manifestly due to the use of rounded river boulders in the masonry, instead of cut stone, as at Mandi.

The hillsides enclosing the wide Kulu Valley were in many places scored by landslips, especially as seen looking up the Parbati river from its junction with the Beas. Schistose slates, quartz-schists and quartzites prevail the whole way.

Sultanpur (Kulu town).

Sultanpur, or Kulu town as it is also called, is largely situated on a high plateau or tongue of sub-recent river-gravels between where the Beas river and the Sarvari river join. Like Bajaura, Samsi and other villages along the valley bottom, it had especially suffered on account of its varied, mixed and debased styles of architecture, the result of the influx of traders from S. and N. The bazar buildings, being half modelled on the low country style and half on the hill type (presently to be described), possess none of the merits of either. The rounded river boulders used in the walls were in fact not so effective even as sun-dried brick for resisting the earthquake, whilst the use of timber in the walls appears to have been frequently indiscriminate, and often as a mere substitute for stone and without it effectively holding the walls together by any bonding process. Heavy slates for roofing were universal.

Hence the damage to Sultanpur proper, especially the older part on the W. slopes of the plateau, was very considerable (see pl. 13, fig. 1).

The palace being rather more strongly built had not suffered quite so much, the temple moderately so (see pl. 13, fig. 2). The lower town and bazar, situated below the high level plateau, had been considerably ruined, though much had been repaired by the date of my visit (19th May). A stone-built Shiva temple, like that at Bajaura, had stood but the top stone, the *amalaka*, had been thrown one portion S. W. and one W. S. W. (See fig. 19.)

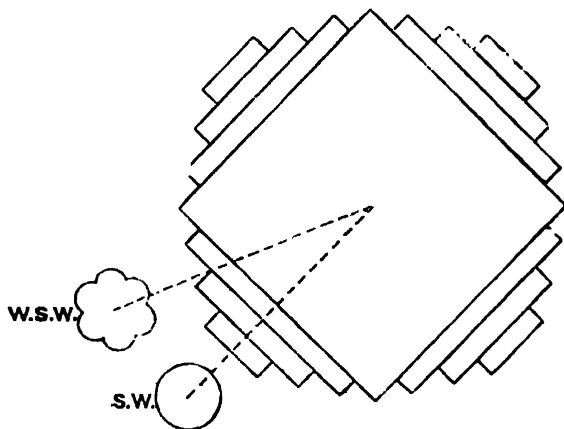


FIG. 19.—Plan.

On the wide camping ground south of Sultanpur the travellers' bungalow, hospital, post office and *tahsil* had suffered considerably but not so much as at Bajaura. They were being repaired as they stood without completely dismantling. At the time of my visit this camping ground was covered with tents belonging to the Assistant Commissioner (Mr. Calvert) and to other officials of Kulu who were gathered together there. There was also a camp post office and hospital.

The following account by Capt. A. T. Banon of Manali of the Upper Kulu Valley is taken from the *Pioneer* of April 27th, 1905 :—

Whenever in Kulu houses were properly constructed in the old timber and stone style, no damage or loss occurred ; and to this also I must ascribe my own

welfare and security. For the two minutes the earthquake lasted I observed with curiosity, awe and alarm, the strange gyrations and contortions of my bungalow, and when it was all over I could not persuade myself that my bungalow was very much in its former state, and not a heap of ruins. In the Upper Kulu Valley the damage and loss of life was nearly all due to immense rocks and boulders tumbling down from above on to the houses. At Sunag one huge rock rolled out a house as flat as a pancake, killing all the inmates, eleven in number. (See pl. 14). * * When the earthquake came it precipitated several miles of snow into the Manali R. The fall of this snow generated a whirlwind, or snow blizzard, which, besides the old fort, damaged several of the houses. To me it looked like smoke, and although the morning was cloudless, and the whole subsequent day was cloudless, five minutes after the earthquake we were enveloped in a dense mist, composed of snow particles, for several minutes. This fall of snow also blocked up the Manali river for a day or two; and even now there is very little water in the river, and what there is very muddy.

The earthquake did not extend above two or three miles from Manali: and the villagers in Palchan, Kolang and Koti near Raila at the foot of the Rhotang pass, which were buried in snow, were unaware that anything had happened. From this one would suppose that there was no earthquake in Lahoul: but the Lahoulis say there was, and that five persons were killed and injured at Kailong, where the Moravian missionaries reside. * * *

As Mr. Calvert and a medical officer with hospital assistants were just about to start on a journey into the higher valleys of the Parbati and Malana rivers, I was kindly invited to join them, and so was able to visit an area which would have been difficult of access by myself alone at such a time.

Sultanpur to Manikarn.

The Buin bridge being destroyed, our party crossed the river by the wooden bridge above Sultanpur. We then ascended to the Borso pass which crosses the ridge-spur north of Bijli temple, 8,076 feet, and so down to Tipri and Channi on the Parbati river. This climb was necessitated by the low road round the precipitous Jiya spur having been destroyed by landslips.

The long gentle slope from the Beas river up to the pass, a total ascent of about 1,000 feet, was not remarkable for much damage to the villages and hamlets situated thereon. This at first sight appeared unnatural on account of the apparently rather top-heavy construction of the houses—all of the hill type—until one came to realise the natural

resisting power of their timber-bonded walls. As all the houses we shall meet with in the description of this part of the Kangra-Kulu epicentral area are of the hill type, differing entirely from the sun-dried brick-built structures of the Kangra Valley, and the mixed structures of the bazars in the valley parts of Kulu, a few words are necessary regarding the method of timber-bonding in vogue, which, whether intentional or not, seems a suitable form of hill architecture for earthquake countries.

Timber bonded houses in Kulu.

I take the following extract from the Punjab Gazetteer of Kulu, slightly abridging it :—

A Kulu hill village is frequently built on a spur or other rocky ground that is useless for cultivation. The houses are generally detached and grouped with a delightful disregard of method and plan. In structure they are very quaint and pretty, like square or oblong turrets much greater in height than in length or breadth and crowned by sloping gable roofs covered with slates or fir shingles. From a foundation of the dimensions 9 *haths* by 9 *haths*, 11 by 9, 15 by 9, 15 by 11 8 by 11 (a *hath* being $1\frac{1}{2}$ feet) the house shoots up three or four stories high. No mortar is used in its construction ; the walls are of dry stone masonry, the stones being kept in place by timbers placed upon them at vertical intervals of 2 or 3 feet. The ground floor is used for cattle and has no windows, the second storey as a granary lit by small windows, whilst the third storey is the living part of the house. Its space area is increased by a more or less closed-in wooden verandah continuous with the upper floor, and protruding outwards from the walls on all or several sides. It is this projecting balcony which gives the houses the false appearance of being top-heavy and unstable (fig. 20).



FIG. 20.

The method of inserting the wood-bonding requires, however, further illustration. In houses of ordinary pretensions this wood bonding takes place at vertical intervals of from 3 to 5 feet. Two parallel beams are laid along the layer of masonry, one on the inside and one on the outside. At the end of one wall they are crossed by the beams of the wall at right angles, and wooden pins hold the crossings together. Cross-ties of wood, dove-tailed or tongued, similarly hold the two parallel beams in position at intervals along their length (fig. 21).

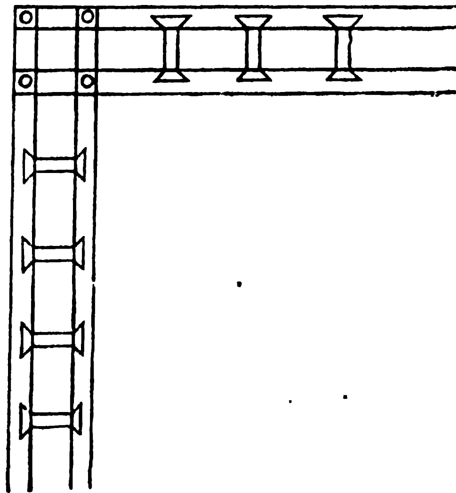


FIG. 21.

Usually rubble masonry, or roughly shaped blocks carefully packed together, occupy the interspaces and form the next courses until another wooden course is begun.

Kat-ki-Kuni buildings.

In the best constructed houses and temples the wooden layers are in continuous contact at the corners of the building, whilst long and beautifully shaped flat slabs of stone alternate with wood along the face of the walls. This style of building is called *Kat-ki-Kuni*, or "timber-cornered," and combines the weight, solidity, and coolness of a stone building with the flexibility

and earthquake-resisting qualities of a wooden one. In the figure the shaded part is stone (fig. 22).

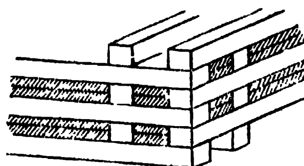


FIG. 22.

In pl. 14, fig. 1, is illustrated this hill type of house structure. The central four-storied tower is built very nearly *Kat-ki Kuni* but it shows the uppermost storey and roof destroyed, probably owing to decay, as the building was old.

Shortly before reaching Tipri village, near Danogi, we crossed several well-marked bergschrund-like fissures separating the rocky part of the hill from the talus and soil-covered fields below, and superposed one above the other. Immediately above Tipri to the north there was a much fissured quartzite cliff with a stream of very muddy water issuing from it which was said to have run muddy since the earthquake, nearly 7 weeks before. The fissure could not be traced continuously into the low ground in the vicinity. Of the surrounding villages those on gravel banks seemed to have suffered most. Many on exposed spurs of solid rock had escaped wonderfully.

Jari.

During our second march from Channi to Jari the rocks, which are exposed the whole way, gradually take on a more metamorphic aspect and become true mica schists, frequently with garnets, and white quartzites and quartz-schists. The precipitous quartzitic scarps of Gagyani Dhar on the N. E. slopes of the Shat Nal, which enters the Parbati river from a S. E. direction, were seen to have been much scored by landslips, a few of which may be recognised in the distant view of the valley beyond Tipri village (see pl. 14, fig. 1). In the neighbourhood

Rock avalanches in the Malana glen.

of Jari also, where rocks along the same strike come into prominence, and where the wild and

picturesque gorge of the Malana glen unites with the Parbati, the rugged crags of white quartzite and quartz-schist had crumbled extensively during the earthquake. From these cliffs, which are frequently crowned by patches of inaccessible forest, the steeply cut gullies now poured down torrents of the white debris, resembling snow culoirs in the distance (see pl. 15, fig. 1). Every now and then a portion of the mountain could still be seen to be "smoking" where slipping areas, had not yet attained the angle of repose. Along with the rock, acres of fine deodar forest had frequently been involved in the falls; a near or telescopic view of which presented a scene of colossal wreckage impossible to describe. It is views such as those illustrated in plate 15 that demonstrate how potent a factor an earthquake may become in the denudation of a region characterised by precipitous cliffs. In spite of this wholesale shedding of scarps, the villages round about generally showed but little damage. Whole villages had sometimes escaped, and others, such as Jari, had only a few houses partially wrecked. Portions of Chowki village, opposite Jari (seen in the foreground of plate 15, fig. 1) situated on a narrow gravel terrace were, however, destroyed, and among the inhabitants some serious surgical cases awaited the visit of our medical officer. The wooden cantilever bridge (of native design) across the Parbati at this point had escaped with nothing worse than a bad wrenching. The travellers' bungalow was intact and habitable. A careful examination of the whole road and lower valley for signs of faults or tectonic movements showed there were none such. All fissures that could be seen were local and superficial. Thus, notwithstanding the torrents of shed rock and forests reduced to matchwood, the comparative energy of the shock here must have been so much less than in the Sultanpur valley that we are, I think, warranted in drawing isoseismal No. IX between these places.

Manikarn: Hot springs.

Between Jari and Manikarn the geological conditions remain much the same, quartz-schists predominating most of the way, followed by schists and a band of gneissose granite crossing the river a little way below Manikarn. Landslips

and rock slides were again seen here in profusion, some being still active as shown by occasional wreathing puffs of dust smoke. Manikarn, which presents some beautiful examples of *kat-ki-kuni* architecture had but very slight damage, except to some roof slates and to one or two houses where rocks fell from the cliffs above. Of the several temples here, including an ancient stone-built one resembling that at Baijnath, none were damaged. The people said that the village did not rock much, but that the hills did so, and scattered fragments all round. The celebrated boiling springs had not been affected by the earthquake, except that they had slightly varied their points of exit. The large one by the river side at the west end of the village was seen to be in full operation, and giving off clouds of steam visible from afar. At one of the covered bathing places the source of the hot water had been cut off. Another spring in a private house was shown to us, still flowing, although for 8 days after the earthquake it had dried up. These springs deposit masses of yellow calcareous tufa, and they also throw up small white seed or pearl-like bodies called "manis," which are prized as ornaments and mementoes. They also give off sulfuretted hydrogen, and stain the rocks, drains and baths a reddish-brown colour. At Manikarn the valley narrows considerably, and there is not very much more in the way of habitations further east towards the source of the Parbati R.

Manikarn to Naggar *viâ* Rashole and Malana.

Shattered crags near Rashole.

Returning part of the way down the Parbati as far as Shallal, we next ascended the steep little V-shaped valley of Rashole. On the way we passed across numerous rock avalanches, then between frowning cliffs of quartz-schist and under still smoking rock torrents that had left a trail of stripped and dead deodar stumps showing far above our heads. The slipped surfaces of the latter always showed some pale green mica along foliation and shear planes. The sheared and splintered condition of this quartz-schist must have been a potent factor in assisting the landslips and

rock avalanches. At Shallal and Rashole slabs of this rock, much heavier than convenient, are used as roofing material.

Damage to village.

Rashole village itself, a group of old and weather-beaten houses of the regular hill type, evinced some damage, one out of a dozen buildings having sagged, sunk at one end, or bulged, owing to some of the horizontal timbers having rotted or burst away from their corner pins and cross-ties.

Malana

The route from Rashole to Malana took us over a pass of 10,600 feet among schistose strata with thin bands of gneissose granite forming the fir-clad craggy summits near the pass. These beds, like those met with at Manikarn, appear in apparent order above the quartzitic rocks. A steep descent of 1,000 feet on the other side of the pass through forests of fir, spruce and larch, and then over gentle slopes below, brought us to the Malana gorge, with its two villages resting on the platform made by the upper surfaces of the quartzites, at an elevation of about 8,600 feet. The precipitous ravine stretching away to the Parbati, lay below us, with its already described shattered sides, a fresh rock avalanche taking place the evening of our stay there. Whilst these rocks had everywhere yielded under the strain of the earthquake the schistose and gneissose rocks which continue above them, both on the Rashole and Naggar routes, had remained comparatively unaffected. Only a few houses, and those old ones, had suffered from the earthquake by leaning, bulging, and partial destruction of the roof, etc., but the majority of the private houses, the grain house, temples and other buildings, all in the beautiful and efficient timber-bonded style, appeared (so far as we were permitted to see them by their conservative inhabitants) practically undamaged.

Naggar.

Malana to Naggar over a steep pass of 13,000 feet, still snow-covered (27th May) on the crest and N. slopes, the extensive view from the pass up to the great open valley and snow-fields that constitute the source of the Malana stream also yielding no fresh earthquake data, until quite near Naggar

itself, when houses began again, one or two of which were partially ruined.

House damage at Naggar.

At Naggar itself, the "castle," which is an extensive and ancient native built timber-bonded house, the residence of the Assistant Commissioner, had suffered on the side towards the river which is rather steep. It presented many fissures in the walls and soil along the line of the declivity and was not in a permanently habitable conditi The Executive Engineer's house, a double-storied modern building, a mile away on the nearly horizontal gravel terraces, had not been much damaged except in its upper story. On the other hand Colonel Rennick's house at Naggar, which is situated on a spur from the main range with a steep slope to the N., had been much more conspicuously fissured, and much damage was done to furniture and other articles within. General Osborn's house, placed in a little bay in the hills and fixed on solid rock, had almost entirely escaped the shock; and its owner told me that nothing inside was damaged, not even pictures, crockery, or glass. It was a well-built modern house, stone below and wood above. Among the native houses the damage done was irregular, but I should judge not greater as a whole than at Jari, Manikarn or Malana.

Fojal Nullah dust cloud.

Whilst here, a point on the main range, 8 miles due W. of Naggar at the head of the Fojal Nullah, was seen to be giving off a dense black dust smoke in a thin ascending column, and I was informed by Mr. W. H. Donald, Executive Engineer in Kulu, that a similar dust cloud was seen at the same spot on 24th May 1894, and that it kept rising for four months afterwards. It was accompanied by a flood which did some damage in the lower parts of the nullah. On the day of the present earthquake also the water of the same nullah where it joined the Beas river ran black with mud in suspension.

A number of aftershocks were experienced here during my stay from 28th to 30th May (for which see list of aftershocks).

Beyond Naggar to the north I did not personally investigate the earthquake, but an account by Captain Banon, relating to this part,

as well as to the area N. of the Dhauladhar, will be found at pp. 58 and 75.

Naggar to Barwar Lake.

During the 31st May and 1st June I marched back along the Beas valley to Bajaura, finding nothing fresh to remark on the way. From Bajaura to Larji the route continues along the Beas valley. During the early part of the journey and about 1 or 2 miles from the former place there is some massive limestone of white, grey and sometimes pinkish colours on the right bank of the river. After this come schists the whole way until 2 or 3 miles from Larji, when white and grey limestone or dolomite sets in. This rock forms a narrow gorge for the Beas, and there are numerous slips, which had temporarily blocked the road but which had since been cleared away and a fair pony track made. The dip is steep, the strike being generally along the course of the river.

Beas valley below Bajaura.

The damage done to buildings the whole way was not great, or at least very little was visible at the time of my visit. Most of the houses of the hamlets along the valley were mud-walled and grass-roofed, low buildings, which either had not suffered or had been rebuilt. On the distant hill-slopes some of the timber-bonded stone buildings could be seen, but rarely. On the whole this part of the route was sparsely inhabited. At one place, only, I noticed a house said to belong to the Rajah of Mandi which had been considerably damaged, most of the roof and some of the walls being destroyed.

Damage to buildings.

A little way below Larji the course of the Beas is deflected to the W. S. W. It ceases to occupy the wide strike valleys and plunges by profound gorges transverse to the strike of the rocks and to the general run of the main ranges. At the point of deflection, surrounded by rugged precipices on all sides, the Sainj river meets it from the S. E.

Deep gorges Larji.

Slips and rock avalanches near Larji.

This river focus had been prolific in landslips during the earthquake, a result to be expected from the way the gorges close in and increase in the steepness of their slopes at the water level. Immediately opposite Larji where the roads takes a V-shaped curve up the Sainj river the hill spur between it and the Beas was terribly shattered, and the ever-moving talus cones being too wide for travellers to cross in safety, a temporary rope bridge had been thrown across the Sainj at a point below them. The rock of the spur showed intensely crushed limestone, slate, epidiorites and diorites in the form of either dykes or interbedded masses. The general strike is (as usually in this reach of the Beas) N. W.—S. E. and the dip N. E. at 40°—60°. Looking up at the much-riven spur from the bed of the Sainj on the Larji side, one had to crane one's neck to see the summit which made an angle considerably over 40°. Two long and narrow debris cones descended the crag from fissures in its upper parts and met at the bottom. These were still in a constant state of movement when I was there, two months after the earthquake; and every now and then they discharged small rocks and dust, the latter being caught by eddies of wind and blown up in clouds, giving the appearance of rising steam. I attribute the same origin to these fissures as to those at the head of the Neogal gorge, namely, gravitation acting with the earthquake shock. I could see no trace of any primary fissures extending deep into the rock such as might have caused the earthquake itself or been part of its original manifestation. Near Larji some caves are said to have fallen and killed some shepherds with their dogs and sheep.

Lake up the Sainj river.

A lake had been formed some few miles up the Sainj river, but although I penetrated some 1 or 2 miles up-stream, I found it impossible to reach it by the river-bed route. In the distance on the left bank could be detected further fresh land-slips and active screes which doubtless were in the neighbourhood of the dam that had temporarily caused the lake.

The travellers' bungalow at Larji was seriously damaged and not weather-proof, but the verandah could be used.

Difficulties of road communications near Larji.

So great is the shattering of the hill-spurs in the neighbourhood of this river focus that I anticipate considerable difficulties for many years to come along this route from Simla to Kulu. At any moment expensive bridges and miles of difficultly constructed road may be carried away by a fresh landslip.

Damage to slopes and villages between Larji and Barwar lake.

Ascending the deep rift of the Tirthan river from Larji, for about 4 miles to Barwar hamlet and the newly formed lake, the same rocks as at Larji, together with quartzites and quartz-schists continue, owing to the general strike remaining constant. They also present a similarly smashed condition, the limestone in particular being much brecciated and having a crumbled and greatly weathered aspect. The slopes also are very steep, and towering crags of limestone have frequently discharged enormous rock avalanches into the valley below. Twara, a hamlet of a few houses, had suffered severely, and 6 out of 30 inhabitants had been killed. Kotla, a large village with high, double-storied timber-bonded houses, had also been much smashed as to its roofs and upper stories, and the inhabitants I was informed had left. It lies about 1,000 feet above the big landslip which formed the Barwar lake. Several other little hamlets on the way were also almost ruined. Generally in this valley, not only as far as Barwar but beyond to Plach, the extra damage to hill-sides and house property may be attributed to the steep angle of slope and the crumbled condition of the rock material.

Barwar lake.

The Barwar lake on the Tirthan river, like the similar lake on the Sainj, was formed by a dam of slipped rock falling athwart the stream. The lake lay in a deep gorge roughly of a reversed S-shape, and it gradually lost itself to the S. E. in the Tirthan river itself. It was from 100 to 200 yards across in its widest part at the time of my examination of it, and about ¾ mile long. The dam was necessarily at the N. W. end, and the broken

face of the hill from which it came was of a roughly crescent-shape, about 300 yards high, and about 200 long. The level of the lake above the lower part of the outflow was, on 3rd June 1905, about 60 to 80 feet. The fallen rock composing the dam was white and pale ochre coloured limestone, and dipped originally at high angles. The water in the lake was not altogether confined,[1] but constantly overflowed to the N. W. forming a rapid. On account of the steepness of the fallen debris cone, which lay at an angle of about 40°, and rose 100—150 ft. above its present base forming the dam (see pl. 15, fig. 2), it is probable that the wash of the outflow water will periodically bring down more stuff from the cone, and so rejuvenate the dam from time to time; but there is no apprehension of any dangerous flooding from the ponded water, which already in the summer of 1906 had ceased to exist as a lake. A suspension bridge, which crossed the valley where the fallen debris now lies, had entirely disappeared from view; and the road following the bed of the valley along the S. W. side was entirely submerged under the lake.

Slopes surrounding the lake.

The spur of the hill facing the slip is a steep and narrow ridge with another gap between it and the main ridge, which gap indicates an ancient channel followed once by the river when the valley was much less excavated than now. This spur and its N.E. slopes are much fissured parallel to the length of the ridge and to the lie of the valley. A few houses perched on it were completely destroyed, and one still standing was in a hopeless condition. The ridge descends abruptly to the N. W. in a steep precipice opposite the slip, and later on may also, in common with the debris cone, contribute to the maintenance of the dam by landslips from it. Generally, also, the lofty and precipitous limestone crags which descend to the shores of the lake were in a much slipped condition, whilst to the S.W. of the lake the shattered slate slopes (along which the temporary road now goes), and the few interbanded layers of limestone, are all in a most danger-

[1] Except for one day when I was informed the people ran down the dam slope and made their escape from the valley.

ously unstable condition ready to give much trouble during the rainy months.

A true rock fissure.

At one point on the lake-side was a new or freshly reopened line of faulting with a steep hade to the S. W. cutting through limestone and slates—the only fissure I have so far seen that might possibly be connected with some deeper fracture, and not due to gravity, combined with the earthquake, for its causation.

Between this place and Manglaur isoseist No. IX is estimated to lie.

Barwar Lake to Jibhi.

Damage between Barwar and Manglaur.

The hamlets on the way to Manglaur, especially Ratwa, were much damaged. All were built *kat-ki-kuni* style, two or three stories high, and in isolated tower fashion like Tipri (see pl. 14, fig. 1). A few of them (probably old buildings) had subsided whilst others were damaged as to roofs, walls, etc. The travellers' bungalow at Manglaur was not much damaged and some of the rooms were habitable.

Manglaur to Jibhi.

In the long and steep gorge cut out of slates and schistose slates between Manglaur and the bridge below Plach, I found a diminishing amount of destruction. Here and there the timber-bonded houses and towers showed some damage, frequently the result of old and decayed timber. Plach lies considerably above the level of the river-bed above Srai and other hamlets, and I could not see how it had suffered. The bridge, a rather long wooden cantilever, had suffered no ill effects; and the road the whole way was in good order. From the bridge to Banjar everything was much the same. Banjar itself had been somewhat damaged as it was built bazar fashion in a row of shops of different heights. The tahsil and hospital buildings had suffered slightly, as also had the distant villages seen from Banjar. On ascending the narrow side valleys to Jibhi, house damage became less noticeable; and the hill-sides were intact until within 2 miles of Jibhi, where white, granular quatrzite associated with black slates had caused a few minor rock avalanches.

Jibhi.

The Jibhi travellers' bungalow was built *kat-ki-kuni* as regards it walls, and remained intact except that the roof where the chimney protruded had fallen (in part) and the verandah supporting a roof of heavy thick schistose slate had been thrust laterally out of the vertical. Many of the servants' quarters were damaged and a village near was burnt down during the earthquake. This is the only instance I came across of fire playing a destructive rôle. The tall fir trees surrounding the bungalow were said to have swayed so much as to threaten to fall, but they did not.

Jibhi to Luri.

Jalori pass.

The track up to the Jalori pass, 10,680 feet, takes one along the members of the same rock group of quartzites, quartz-schists, limestones and slates—sometimes carbonaceous—but no further rock falls were noticed, except quite close to Jibhi itself. The strike curves round from N.W.—S.E. until it becomes N.—S. at the pass. Near here a very prominent, detached pinnacle of rock, with vertical sides still stood insecurely perched on the slope of the ridge and supported a cluster of growing fir trees at top.

Kot.

The village of Kot on the S. side of the pass, a picturesque group of houses in the timber-and-stone style, straggling down the crest of a little ridge, was almost the last along this route to show any considerable damage, walls being bulged and roofs partly destroyed; whilst the travellers' bungalow, still further down the rugged and precipitous spur, had similarly bulged as to its walls. The roof also had become insecure, and consequently the heavy slates had been removed by hand prior to my arrival. Like the Kot houses it also was timber-bonded, but not *kat-ki-kuni*. The heavily canopied gateway of the enclosure of the hill temple, which somewhat resembled the lich-gate of a country churchyard in England, had likewise collapsed. The strike of the rocks had further changed at the S. side of the pass, and now was N.E.—S.W., with the dip to S.E. at moderate angles of 15° only, down the slope of the hill.

Chawai.

At Chawai, the next stage, the bungalow was habitable, the chimneys only having fallen; but on the way there, in the steep-sided nullah into which the road dips, there was still some notable damage to old buildings; roofs and a few walls having succumbed. Beyond that point all serious injury to buildings ends, and consequently isoseist No. VIII has been drawn between Kot and Chawai.

Dalash.

The road to Dalash, like that from Jibhi, showed no destruction to hill-sides, and, as for buildings, only a few tiles were displaced. The travellers' bungalow was intact, even the chimneys remaining in position. A few roof tiles were slightly displaced, and there were fine cracks in the plaster of the walls.

Luri.

No damage was apparent on the way to Luri, and the bungalow had not a single crack of any sort. The suspension bridge over the Sutlej river exhibited one or two insignificant cracks, but there was no real injury of any sort beyond the wide and very open valley of the Sutlej, which with its sub-recent gravel terraces, 500 to 600 feet above the water level, forms a striking contrast to the contracted river-gorges of Kulu between Bajaura and the Jalori pass.

Luri to Simla.

The long steady ascent to Narkanda showed no visible effects of the earthquake, but I was informed that here and there house walls showed tiny cracks. The rest of the way to Simla was similarly barren of any visible result, hill-sides and villages with their staging bungalows appearing quite normal.

Simla.

At Simla my tour came to an end. In a large hill-station such as this, dotted over a big area of steep slopes, there were, of course, many accounts of chimneys and other minor falls having taken place; but all such had long since been repaired, and the effects of the shock only remained as an unpleasant memory.

Earthquake Forms—Simla.

Ranjeet Singh, Signaller at Chota Simla.—Several minor shocks were followed by the principal shock. Direction E.—W. Chimney of post office fell. No sound.

Mr. S. D'Cruz.—Time 6-12 by watch. House rocked S.E.—N.W. Walls cracked. He experienced a foreshock at 1-30 A. M. on the morning of the earthquake.

Major R. S. Maclagan, R.E., at the United Service Club.—No prelim. tremors. One most severe shock. Distinctly felt, doors and windows rattled, roof creaked pictures swung and bookshelves on walls running N.W.—S.E. fell inwards into the room. No sound.

Mr. A. R. Astburn, Assistant Engineer.—Time 6-10 by watch corrected about every third day by telegraph office. Direction N.—S. He was living in a double-storied house, the lower story being masonry, the upper one "dhajji." The shock awoke him. He left the house. Nothing was upset in the way of ornaments. Water from fire buckets spilled about ⅓ total quantity. No sound.

Mr. B. N. Mass, Sub-Divisional Officer.—Time 6-10 = the mean of times shown by some 10 pendulum clocks, which all stopped, and 4 watches. 1st shock the most severe. Direction N.—S. apparently. Uppermost 14 feet of an isolated tower at the new Civil Secretariat Buildings twisted round contrary to the hands of a watch. Chimney stacks lying E.—W. moved N.— S. and were ruptured at the intersection of the roof. Pendulum clocks showed the same movement. A flat iron masonry tie ¾ inch in diameter in a wall lying approximately N. - S. was burst asunder and the washer 12 inch by 12 inch by ¾ inch was projected with terrific force against a wall opposite. Of high walls (60 ft.), those lying approximately E.—W. showed horizontal as well as vertical cracks at about 10 feet from the top. Glazing in windows lying E.—W. approximately was broken and shattered. There was a loud rumbling sound continuing some 15 to 20 seconds after the shock. Its beginning was almost simultaneous with the shock.

Mr. W. H. Donald, Ex. Engineer, Kulu, at "Chillingham," Simla.—There was a rumble and then the shock came. Direction N.E.—S.W. All doors rattled, rafters creaked and pictures were displaced. No cracks in buildings.

Mr. D. Macfarlane.—Time 6-10 by watch regulated by telegraph office. 1st shock the most severe. Distinctly felt, walls cracked, roof creaked and a few small ornaments fell.

Mr. W. E. Buchanan, at the Municipality Water Works.- Direction N. W.—S. E. taken from 2 filter tanks. The water in the two outer ones which were filled to within 17 inches from the top flowed first over to the S. E. side and then over to the N. W. side.

Captain F. W. Hawks, Indian Army, at "Eric's Own," Simla.—Time just after 6 A. M. One continuous vibration. Trees swayed, bed shook, galvanised iron roof rattled continuously for about 1 minute. Doors jammed tight, walls cracked vertically in some places sufficient to admit the hand. Masonry chimneys

fell from surrounding houses. People rushed out of doors. In house above a heavy almirah was pushed into the centre of the room owing to the bulging of the wall. Church windows were broken. There were a large number of aftershocks following in rapid succession. Miss Hall, nurse in the employ of the above, awoke prior to the big shock, stating that she had felt tremors for some time before. She had partially dressed in consequence.

A *Statesman* correspondent writing on the 5th April described the shock as resembling the "Tremor and oscillation of a large ocean steamer going at full speed in a choppy sea" and adds that the sensation of sea-sickness was experienced. Several houses including Fairy Villa (Chota Simla), Thistle Bank (Barra Simla) and Kendal Lodge (Elysium) were vacated.

Other Routes—(*a*) Chamba to Lahoul.

Before altogether leaving the description of this epicentral tract of the Kangra-Kulu area it will be well to append two descriptions of certain parts of it in the north and south not visited by myself, but of which I possess reliable information. Captain Banon[1] relates that Colonel Hayes, 1st Lancers, found Chamba but little damaged, but the valley of the Ravi about Barmaur and up to Kukti much damaged, especially Kukti, which was completely destroyed. Thence he (Colonel Hayes) crossed into Chandra Bhaga Valley to Kailing in Lahoul. The earthquake was destructive in this valley, but loss of life small. The damage to the Lahoulis' houses was probably due (so Captain Banon thinks) to the want of wood in their construction.

Capt. Banon, Col. Hayes and Col. Vaughan's accounts.

The Thakoor of Lahoul told Captain Banon that such large masses of snow were shaken off the hills that there was a mist of snow for two or three hours after the earthquake, which plunged the whole valley into darkness and added very much to the prevailing terror. A similar occurrence on a small scale happened at Manali in Kulu (see p. 59). Captain Banon also reports that Colonel Vaughan, 7th Rajputs, was shooting in the Solung valley, and he noticed that the earthquake shook off immense masses of snow, 30 to 40 feet deep, into the valley as well as rocks which destroyed

Snow mist.

1 In a letter to the Director, Geological Survey of India

hundreds of big trees. Captain Banon further says the very hot spring of Basisht was turned quite cold, whilst the lukewarm water of Kelat, 4 miles further down the valley, was rendered hot. After a week or 10 days they reverted to their former state. He also mentions the great prevalence of thunder-storms in Kulu during the year of the earthquake, many of them being very destructive to cattle and human beings.

Springs.

(b) Suket to Simla.

The following notes were kindly made for me by Mr. Burkill, Reporter on Economic Products to the Government of India, who had occasion to take the above route in May 1906. Although this was nearly a year after the earthquake, there was no difficulty in obtaining trustworthy information in such out-of-the-way places where life moves slowly and there is no news to distract. The damage reported agrees with what was to be expected, and usefully fills a gap left blank by my own traverses of the region:—

Mr. Burkill's account near Suket.

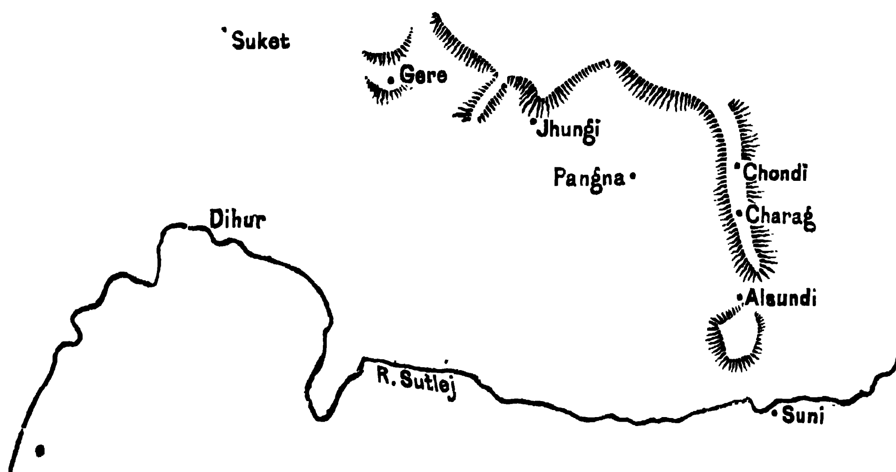


Fig. 23.

Geri.

The road below near Jay Devi slipped at the time of the earthquake where it passes over a patch of gray shaly stuff. Slates fell off the Geri rest-house and the house of the Chokidar and the house of the Lumbardar were badly damaged. At Suket a new spring appeared.

Jhungi.

The earthquake did no damage at Jhungi. The houses here are made of wood and took no harm. It is true that the Chokidar's house at Geri fell; it was an old house with horizontal lines of rotten wood in between the stones. At Geri it is the practice to build with stone. There was a vertical crack found in the wall of the bungalow at Geri. The bungalow at Jhungi though outwardly of stone has a lot of wood in it. People ran out of their houses at Jhungi, but nothing more happened.

At Pangna is a picturesque fort which was in no way damaged by the earthquake.

Chindi.

The earthquake shook slates off the Chindi bungalow and damaged sundry rotten houses in the neighbourhood. It stopped all the springs, and water has now to be carried some distance (2 miles).

Alsundi.

The earthquake shook down corners of some dilapidated houses, but did no damage to good houses. A spring opened where none had been before.

Charag.

The earthquake shook a few old and rotten houses in this village and slightly altered the springs which in some cases emerged at different points, but there is plenty of water near Charag. The rest-house on the hill top was damaged in this way. Over the window on the right hand side the masonry was twisted so that there are two obliquely vertical cracks, and the same side of both cracks is thrown forward out of the plumb in one case two inches, in the other case one inch.

A third crack runs from the corner of the window through the top of the door near it round by the top of the window to the front door of the bungalow. Inside a lot of plaster had fallen but the wall is not damaged.

Owing to the dilapidated state of this bungalow which is of the common type in Suket, it is easy to see how the walls are made. They are made of stones of all shapes carefully fitted together without cement, covered with about an inch of plaster.

I have been more than a fortnight in these hills and have felt no earthquake shocks, but at Chindi I was assured that there had been an earthquake five days before my arrival and another twelve days before; and here at Alsundi the Chokidar says that there was an earthquake at 3-30 this afternoon. Not one of them have I felt.

CHAPTER II.

MUSSOORIE-DEHRA DUN EPICENTRAL TRACT.

In the final part of Chapter I, it has been shown that the destructive energy of the earthquake, as recognised at the surface of the ground, showed such a well-marked decline between Larji and the neighbourhood of Kot, and was followed as far as Simla by an area so much more uniform and of so much less intensity, that we may be said to have emerged from the epicentral and meizoseismal tract altogether. This now-entered-on area of much more uniform and less intense destruction continues to surround the Kangra-Kulu epicentral tract, and to be everywhere followed by still wider zones of still less intensity—except in one direction only, namely, that of the immediate neighbourhood of Mussoorie and Dehra Dun, where a slight but marked increase sets in. This has already been considered in my preliminary report to indicate a second minor epicentral tract in the latter area. Partly on this account and partly because of the importance of the large town of Dehra Dun and Mussoorie, a separate description of this minor epicentral area was desirable. Two officers of the Geological Survey were deputed to this region, namely, Messrs. R. R. Simpson and K. A. K. Hallowes, and the account now to follow is largely the result of their work. It is supplemented, however, by a considerable number of independent local accounts furnished by direct report and by the filled-in earthquake forms by officials and private residents. These are more numerous than in the case of the Kangra-Kulu epicentral tract, where the mortality was too great and where rescue and relief work were too urgent in their demands to allow leisure for scientific reports.

ological struc- tu

In geological structure the Dehra Dun and the surrounding part of the hills resemble the Kangra Valley area on a small scale. The valley of the Dun itself is occupied by sandy alluvium resting on sub-recent gravel deposits and consolidated debris fans which in their turn overspread the folded Upper Tertiary

rocks of the Siwalik and Nahan stages. The main boundary fault separates these from the older slates and limestones of the Mussoorie ridge, just as occurs north of Dharmsala in the Kangra Valley generally, and along the Guma-Drang-Mandi line of country already described.

Dehra Dun Town.

Dehra Dun, besides being a large native town and the cold weather head-quarters of the district civil staff, has also several battalions of Gurkhas in cantonments. It is also the head-quarters of the Trigonometrical and Forest Surveys of India, of the Agricultural Chemist and Cryptogamic Botanist to the Government, and of the Forest School. The Imperial Cadet Corps, and the Viceroy's Body-Guard and private stables are also accommodated here. It is consequently a town of considerable size, importance and variety as regards buildings.

The following notes are by Mr. R. R. Simpson :—

Construction of buildings, etc.

Dehra Dun is built on alluvial sand and boulders, the foundations of buildings being usually composed of a layer of from 1 to 4 ft. of concrete. The buildings are constructed of burnt brick with lime mortar, of boulder masonry with lime mortar, of unburnt brick with mud mortar, or of combinations of these materials. Of these classes the first three are mentioned in order of merit as resisters of damage due to the recent earthquaking. The value of the last group naturally varies with the kind of combination. With regard to roofing the following different types[1] in use (pl. 20), are mentioned in order of merit solely with reference to the assistance which they render to the walls on which they rest (1) arched roof with iron ties; (2) jack-arched roofing, *i.e.*, composite arches with steel joists, the last arch on either side being tied to the walls; (3) flat terraced roofs, usually with wooden beams; (4) bent roofing of galvanized iron on light, wooden framing; (5) thatched roofing.

1 Sketches of these types figs. 1, 2 and 3 with explanation were kindly furnished by Captain A. Anderson, Executive Engineer, Public Works Department.

Well-built erections of brick, usually with tied or jack-arched roofs, have suffered little, whilst some few, such as the Public Works Department Executive Engineer's office have escaped unscathed. The damage throughout the station and in the bazars, is, however, very serious, and a large number of buildings will require to be re-constructed.

Details of damage done in Dehra Dun.

Binfield, No. 24 Rajpur Road.

This is a double-story bungalow facing west. Its walls are two feet thick, and in the lower story are of unburnt brick, the upper story being a combination of boulder and burnt-brick masonry. The building is poorly constructed. The corners of most of the rooms have opened out, often as much as one inch of separation being measurable. The principal damage is to walls running E.—W. The cracks approximate both to the vertical and horizontal but usually follow lines of weakness. The roof is of galvanized iron carried on wooden beams. Neither it nor the floors have sustained injury.

Articles of pottery standing on brackets running E.—W. were thrown down, whilst those on shelves at right angles were unaffected.

Principal direction of motion probably N.—S.

No. 33 Rajpur Road.

Double-story building with walls 20 inches thick constructed of burnt brick. Faces S. 10° E. The upper story is wrecked the corners of most of the rooms having opened out. The main cracks in the walls run from N.E. to S.W. Principal direction of motion was N.W.—S.E.

St. Thomas' Church.

A well-built structure of small, burnt bricks, aligned N. 45° W. It has sustained no serious injury. The worst cracks are those which follow the junction of the nave and transepts. The transepts were additions to the original building, and consequently their separation can be understood. An old crack in the arch at the N.W. end of the nave has opened out further, but the tower above it is undamaged Several window arches show slight cracks at the crown, particularly that at the S. E. end of building.

Principal direction of motion N.E.—S.W.

Imperial Forest School.

Well-constructed building of burnt brick, with steel beams and jack-arched roofs and ceilings. The principal crack runs N. 25° E. Most of the damage is in the upper story, where the corners of the library have opened out slightly.

Principal direction of motion was N. 65° W.—S. 65° E.

No. 18 Lytton Road.

Single-story thatched bungalow of poor, unburnt brick. Faces N. 30° E.

Projecting bay on north front was thrown out completely, and the whole building was badly shaken. Chief cracks run in N.—S. direction.

Principal direction of motion was from west to east.

No. 3 Lytton Road.

Single-story, thatched bungalow of mud and unburnt brick. Faces N. 60° W. Wall facing S. 30° W. fell down towards both sides.

Principal direction of motion was N. 60° W.—S. 60° E.

Club.

A single-story brick bungalow of recent and good construction. Is one of the few buildings which show only a few very slight cracks.

Jail.

The worst-damaged building is a long barrack aligned N. 80° W., and built of boulder masonry tied with burnt brick. Only slight cracks show in the longer walls, but the end walls are badly fractured diagonally, as shown in fig. 24.

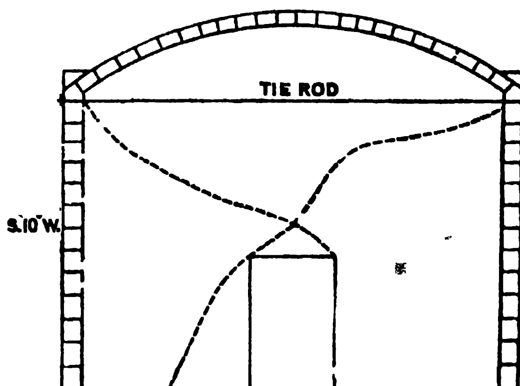


Fig. 24

The quarters of the jail-warders are situated outside the jail. They comprise a long barrack aligned N.—S. Three cross-walls out of six have collapsed, whilst the longer walls are cracked at many points.

Principal direction of motion was W.—E.

Sessions house.

The chimney at the south end fell to S. 12° W., but this direction coincides with that of the slope of the thatched roof through which it passes. The corners of most of the rooms have opened out slightly. The principal cracks in the walls run N.—S.

Principal direction of motion W.—E.

Cemetery.

No damage visible.

Police lines.

Barracks aligned N. 60° W. One building has been cracked longitudinally from end to end, the fracture being about one foot above the ground. The end walls are fractured diagonally.

Principal direction of motion S. 30° W.—N. 30° E.

Post Office.

Very slight cracks running S. 55° E.

Railway Station.

All the buildings are of substantial brick masonry, and are aligned N. 15° W. The main building is intact, but that used by the refreshment contractors has been considerably damaged. The corners of the rooms have opened out slightly. Walls running E.—W. have been damaged at the top by the motion of the roof-beams, and they also show vertical cracks.

In the goods shed the northern wall was shattered by the motion of the roof-beams along a line parallel and close to the roof.

In the engine shed three out of eight arches on the east face were cracked at the crown. In the south wall a few slight cracks are to be seen, but the large arches are uninjured.

A pendulum clock on an E.—W. wall did not stop.

Apparent direction of principal movement N.—S.

Buildings in the bazar, Rajpur Road.

The houses are chiefly aligned N. 55° W.—S. 55° E., and walls in this direction are more cracked than those at right angles. Several cornices, however, fell to N. E. The octagonal minaret of a mosque measuring

24 ft. by 3 ft., shows a fine but distinct crack round the base, but no displacement has occurred.

In a house belonging to Lichi Ram, banker, walls running N.—S. are cracked diagonally, and those aligned E.—W. vertically. Several ceilings are cracked along lines parallel and close to walls running N.—S.

In another badly-damaged house walls running E.—W. show cracks from one to four inches wide.

A three-story house was injured, the chief cracks being vertical and occurring in N.W.—S.E. walls.

In a two-story house in Dhamawala a wall running N.W.—S. E. has broken away from its companion cross-walls and leans to N: E. The height of the wall is 25 feet, and the horizontal displacement at the top was six inches. In the same building walls running N. E.—S. W. are badly cracked in a vertical direction.

The police-station is a two-story building facing S. 50° E. Walls running in that direction are seriously cracked. The front portion of the building is an addition. It has been separated from the original portion along the line of junction (see pl. 17, fig. 2). Shattering of ceiling plaster which has occurred is clearly the result of the "draw" of beams running N. W.—S. E.

A double-story house, 22 feet high, was completely wrecked. The building faces S. 60° E., and the front wall, 18 feet in length, fell out, carrying with it a portion of the side wall facing S. 30° W. The length of the latter is 7 feet. These fallen walls formed two sides of the front room. An examination of the fractured ends of the walls showed that in many cases bricks had been actually sheared through. Of the remaining walls the worst cracks occur in those parallel to the front of the house. Considering this last fact it is possible that the shorter wall, facing S. 30° W., was the first to fall, and the cause of the fall of the front of the house.

A two-story house facing S. 35° E. suffered severe injury. A portion of the front wall fell outwards whilst the side walls were badly cracked.

Apparent direction of principal motion is from N.W. to S.E.

Roman Catholic Chapel.

This is a massive brick building aligned N. 70° W. It is 75 feet long, and 25 feet in width and has a pointed roof. The longer walls are each supported by six buttresses measuring 3 feet by 2 feet. On the north and south faces more than half of the buttresses are cracked horizontally at points from 2—3 feet from the ground; whilst two of them are separated by cracks from the walls. In the same walls the cracks hade to the east, at angles of 0°, 20°, 30°, and 45° from veitical.

On the east face the porch has slightly separated from the main building. Of the arches in the porch that facing east is cracked vertically at the crown, whilst in those at right angles the cracks hade east at about 30° from vertical. The main east wall shows a crack hading N. at 45°, and also slight irregular fracturing. A well pronounced horizontal crack runs along the wall at the level of the spring of the roof. In the interior the four corneis are slightly cracked. The roof and ceiling are partly carried by a series of five tranverse arches. Everyone of these arches is cracked, and as they are somewhat flat and are said to have been built without key-stones, would have collapsed, but that they are held to the main walls by iron ties. The nature of the damage to two of these arches is shown in fig. 25.

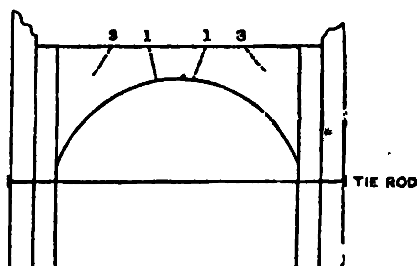


Fig. 25

Apparent direction of principal motion N. 20° E.—S. 20° W.

Mr. R. G. Mclill's house.

Single-story bungalow facing N. 70° W. The arches of the front and back verandah are cracked in a vertical direction at the crown and spring. Walls running S. 20° W.—N. 20° E., show cracks from 0—1 inches wide hading S. at 10°—20°. One crack, however, hades N. at 35°. The back wall runs in the same direction, and has moved out one inch at the top to the east. In walls at right angles the cracks hade W. at 5°—15°, one wall moving $\frac{1}{4}$ inch at the top to the south. Bottles on a shelf parallel to a wall running N. 20° E. fell outwards to N. 70° W. The front verandah is partially separated by cracks from the main building.

Apparent direction of principal motion N. 70° W.—S. 70° E.

Messrs. Hobart and Hampden's house.

This building faces N. 70° W. The damage is confined to the verandah and the front portion of house. The cracks in the former follow structural lines, and are chiefly parallel to the front of the house. In the latter the cracks run S. 20° W. and hade W. at 15°—20°.

A balustrade fell outwards to the south, whilst articles on E.—W. walls fell outwards in the same direction.

Apparent direction of principal motion N. 70° W.—S. 70° E.

Col. Swettenham's house.

Faces N. 30° E. The front of the building fell outwards to N. 30° E. The inner main wall parallel to the above moved out one inch at the top, and is considerably bulged in the same direction. An arch running N. 30° E. fell chiefly to N. W., whilst a main wall in the same direction is cracked vertically.

Apparent direction of principal motion N. 30° E.

Mr. Eccle's bungalow.

Faces N. 50° W. There are numerous structural cracks in the front and back verandahs, and the thrust of the main walls has separated them from the building. The front wall is cracked horizontally about two feet below the roof. It also exhibits strong vertical fractures.

Apparent direction of principal motion N. 50° W.—S. 50° E.

Dehra Dun Cantonment.

Verona Villa.

This is a single-story brick and thatch bungalow facing N. 12° W. The verandah is supported on octagonal brick pillars measuring 15 inches by eight feet. All of these are fractured at the base, and one of them has moved three-eighths of an inch to N. 60° W., whilst others show slight movement to W. and N. W. The pillars are in groups of three, the brickwork being continuous at the base and the top. This connection has been broken at the top, chiefly along an E.—W. line. The western wall of the house has fallen, causing the roof on this side to collapse (see pl. 17, fig. 1). Of the numerous cracks within the building, the most pronounced run E.—W.

Imp. Cadet Corps' new quarters.

Apparent direction of principal motion, N. 12° W. -S. 12° E. In the adjutant's bungalow, a new building now in course of erection, three chimneys, measuring 3′ × 3′ × 10′, were cracked at the base, one of them being displaced to the extent of half-an-inch in a direction N. 60° W. In the cadets' quarters the verandah arches at the four corners of buildings are damaged. The injury is due to the fact that the pillars being unsupported at one end were unable to withstand the thrust of the arches. The damage is precisely similar at each corner, as shown in fig. 26.

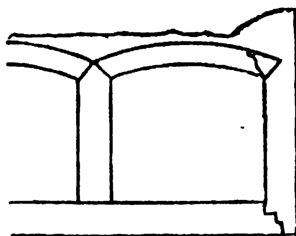


FIG. 26.

The steel and corrugated iron roof of the covered tennis-court is carried 6 feet above the longer main walls by ten brick pillars, each measuring 2′ × 2′ × 6′. These are all cracked at the base. At the

points where the steel roof girders rest on the end walls the brickwork is much jarred, as if the beams had drawn. As, however, the corners of the building are intact, it is possibly caused by up and down motion. The minarets of a mosque near by are cracked horizontally at the base.

Kowlagarh tea estate.

The factory is a strongly constructed brick building, and is little injured. Some very flat arches running N. 5° E. have been cracked at the crown. Several walls running N.—S. have moved slightly to the west. Filled-in arches display cracks round the edge of the filling. The pillar supporting the filled-in verandah arches at the S. W. corner was cracked horizontally by the thrust of the arches. The manager's bungalow is seriously injured. It is a large thatched house facing N. 70° W., and is built of sun-dried brick, except for the arches, which are of burnt brick. On the front face the outer verandah pillars are cracked through horizontally 2 feet from the base, whilst the inner verandah arches display both vertical and horizontal cracks. Wing walls in line with the front of the house have been separated from the building by cracks ¼ inch wide. Wing walls at right angles show even further separation. The cracks in the walls are chiefly vertical. The office is a long two-story building aligned N. 60° W. The lower story is built of burnt brick, and the upper story of sun-dried brick. The junction of the two materials is now shown by a horizontal crack running right round the building. A portion of the S. W. face, in the upper story, has fallen outwards. On the N. E. face two cracks pass through both stories. One is vertical, whilst the other hades 4° to S. E.

The staff lines are built parallel to the office. The end walls display fractures hading N. 30° E. at 5° to 20°. Tiles on a roof sloping S. 30° W. fell in that direction.

The owner's bungalow is a square double-story brick building facing S. 38° W. The lower story is intact except at the four corners, where the thrust of the verandah arches was unsupported. In the upper story a portion of the verandah facing S. 38° W. fell outwards. The back wall has moved out a full inch, whilst walls in the same

direction show cracks hading from 0°—20° in opposite directions. Wing walls running S. 52° E. have separated from the principal structure. The kitchen is a detached circular building. The most pronounced crack runs through it on a N. 15° W. course. Walls of outbuildings aligned N. 60° W. fell to S. 30° W. In the godowns the principal damage is to walls facing S. W., the cracks hading from 0°—10° to N. W.

In a mud-built shed walls running N. 55° W. display cracks hading N. W. at 15° and 17°, another fracture hading S. E. at 5°. The cross-wall fractures hade S. 35° W. at 25°.

In this collection of buildings the principal direction of motion was apparently N. E.—S. W., but there is considerable evidence of motion in other directions.

Estimates of the duration of the chief shock vary from 2 seconds to as many minutes. The general opinion was that it lasted from forty-five to sixty seconds.

Duration and character of principal shock, and direction of impulse, etc.

The quake appears to have begun with mild vibrations which lasted long enough for those who were awake at the time to reach the door. The violent oscillations were two or three in number, dying away in the same manner as the disturbance began. Colonel Burrard considered that the vibrations were horizontal in direction, and had a frequency of about three per second. In his opinion the disturbance ceased abruptly. Many observers detected a distinct rocking motion sufficient to cause trees to sway, and to disturb the balance of those standing or attempting to walk.

Those who were awake at the time record hearing noises which are said to resemble the rushing sound of a gale or a railway train in motion.

From an analysis of my own notes of injury to buildings, etc., and the observations of eye-witnesses the oscillation appears to have come from practically every direction. To a number of competent observers, however, the motion in the case of the chief shock appeared to be

from north to south. The question is complicated by the fact that many of the houses are built on the banks of wide and deep nalas, which must have considerably influenced the direction of principal oscillation of the buildings.

Time of quake.

The general consensus of opinion fixes the occurrence of the principal shock at times varying from 6-9 to 6-12 A.M. (Madras time).

Enquiry at the local post offices, the railway station, and elsewhere shows that in many cases clocks were stopped by the disturbance, but that in few cases was the actual time of stoppage noted before setting the clocks going.

The most reliable time observations were made at the offices of the Survey of India. Through the courtesy of Lieutenant-Colonel S. B. Burrard, R.E., F.R.S., Superintendent, Trigonometrical Survey, to whom I am much indebted for kindly assistance, I have been supplied with full information in regard to the Survey clocks. The chief of these are the sidereal clock, the turret clock, and the clocks attached to the magnetograph, barograph, and thermograph. The sidereal clock, which gives the time to the other clocks, was stopped by the shock, but, unfortunately, the subordinate in charge set it going again without noting the time of stoppage. The pendulum of the turret clock swings from N. 73° W. to S. 73° E. or approximately at right angles to the meridional swing of the pendulum of the sidereal clock. It stopped at 6h. 10m. 30s. (Madras time) and the correction for the clock at 6 A.M. on the 4th was + 34 seconds. Therefore assuming that the clock stopped within 4 or 5 seconds of the commencement of the shock, we have 6h. 11m. 4s. less 4 or 5 seconds, or 6h. 11m. 0s. (Madras time) as the nearest possible approximation. It corresponds to 6h. 2m. 15s. local mean time. In this estimate, however, we cannot be *absolutely* certain that the clock stopped within the assigned 4 or 5 seconds.

The time evidence from the magnetograph and barograph traces is generally corroborative of this, but as the trace of the former can only be read to within 1 minute and that of the latter to within

15 minutes, they will not be considered further here. A report by Captain R. H. R. Thomas, R.E., of the times as registered on the magnetograph curves at Dehra Dun, Kodaikanal, Barrackpore, and Toungoo will be found at p. 292.

Magnetic disturbance previous to quake.

Although the connection between the two events is not obvious, it is interesting to note that a strong magnetic disturbance commenced at 6 A.M. on April 1st, and lasted until 4 A.M. on the 2nd. These disturbances usually coincide with the appearance of sun-spots, but in this case none was visible.[1] Previous to the quake sun-spots had been last recorded on the 2nd of March. The magnetic disturbance of April 1st and 2nd was fully equal to the average disturbance recorded during the passage of sun-spots.

Earthquake Forms—Dehra Dun.

[NOTE.—As Mr. R. R. Simpson's special report on damage to buildings in this town has just been given, the summary of the earthquake forms which follows only reproduces remarks referring to such when they are of special interest. As the question of the time of the main shock has also been gone into exhaustively by the Trigonometrical Survey officers for Dehra Dun itself, it is also useless reproducing a large number of mere guesses. Personal impressions of the shock are given in some detail as their place could not be supplied by later investigation. Aftershocks are all grouped together in a separate chapter of this volume. As already explained in the Introduction, it has been found impossible to quote every one owing to evidence repeating itself and to lack of space. All sleepers were awakened.]

Ram Ratan, Overseer, P. W. D.—The motion was like a machine sieve worked by an engine. Bottles, clocks, etc., on shelves facing W. or E. fell. Buildings of Indian Cadet Corps under construction (without roofs) suffered more than those with roof complete. Hanging lamps swung roughly E.—W.

Col. G. Strahan, R.E.—The first shock was violent and lasted about 50 secs. in violent phase. (N.B.—The writer has had great experience in time measurements in astronomical observations and thinks 50 secs. correct.) Chimneys were thrown clear one to the N. 8° E. and one to S. 8° W. The water of many tanks washed over the N. side. Hanging lamp swung through 15° of arc in all direc-

[1] Solar photographs are taken twice daily at the Survey of India Offices.

tions as seen one minute afterwards. Pictures thrown as much as 30° (measured) from the vertical. Those on E.—W. walls more disturbed than those on N.—S. walls. Pendulum clock with plane of vibration nearly due E.—W. did not stop. Trees swayed and leaves rustled. There was a sensation of considerable horizontal motion rather than of a passing wave. House (a "kutcha" thatched bungalow) cracked everywhere. People rushed out. He was detained 20 to 30 seconds by a jammed door.

E. R. Stevens, Offg. Deputy Conservator of Forests.—A whisky bottle, soda water bottle and glass fell N.—S. on table. The sound like string of bullock carts passing on a road. It was a continuous sound.

Mukundananda Acharya, Meteorol. Observer.—Describes general panic, and that many passed the night outside. Bottles and light articles fell generally E. and W. Most house cracks were vertical.

Mr. C. B. Lall, Signaller.—Chimneys rocked from W.—E. There was a rumbling sound off and on, heard the strongest at the first shock. Doors and windows banged, roofs creaked and ornaments fell off their stands.

Babu Abdul Jabil, Head Clerk in Dist. Engineer's Office.—Time 6-10 A.M. by 2 clocks and a watch keeping G. T. Survey time. The clocks stopped. Four distinct shocks, 2 vertical and 2 horizontal. Slight ones from W.-E. and 2 most terrible ones. Total duration of shocks 35 secs. (guessed). Bottles and phial on shelf fell E. Noise like railway train in distance. He fell down with the shock, and was much alarmed thinking the roof would fall.

Mr. O. C. Ollenbach, Survey of India.—Time 6 hrs. 10 mins. 30 secs. (Madras time) by clock in G. T. Survey Office (uncorrected), which stopped. There was a noise before like the approach of a great storm. 2nd, slight shocks for about 2 secs. 3rd, 3 very distinct and severe shocks in very rapid succession. 4th, several others decreasing in force till all was quiet. A lamp fell from S.—N. Vase from E. to W. Pot on chimney fell E.—W. Lamp swung from S.—N. The sounds continued till the shocks had nearly ceased. House cracks vertical from above and one horizontal one near the floor.

Birbal, Asst. Instructor and Curator, Imperial Forest School.—There were 1st tremulous vibrations, which he thought were palpitations of the heart. 2nd, distinct, irregular and sharp oscillations for 2 mins. 3rd, the movements died away regularly. Direction S.—N. by trees and fall of library wall. No sound.

Lieut.-Col. S. G. Burrard, R.E., F.G.S.—The vibrations were horizontal and about 3 per second. After long habits of timing stars and pendulums he can state confidently that the complete period of the vibration was distinctly longer than ¼ sec. and less than ½ sec. He thinks that they were the direct vibration of the ground and not those of the building where he was sleeping. Time 6-11 (Madras time) from two pendulum clocks in the house whose error was known to within 2 mins. No prelim. tremors. One big shock which stopped suddenly. Direction N.—S. No sound. Vases fell to the ground from brackets on N.—S. walls, Those on walls running E.—W. did not fall.

Mr. H. G. Shaw, Survey of India.—Time 6-10 by watch correct with Survey Office turret clock. Direction N. E.—S. W. Sensation like when steamer anchors (? dropping anchor).

Mr. P. Owen, Station Master.– Direction N.—S. Large shells (ornaments) and bottles fell N. W. Sound like wind through a hollow tube was first heard followed by the main shock immediately.

Capt. D. Cameron, Imperial Cadet Corps.—He first thought it was a dog under the bed, and then the end of the world. Slight vibration at first, increasing to a violent rocking motion. Duration 40 secs. A roaring and rumbling noise. Wine bottle fell in cupboard of N. wall. Fern basket in verandah swung E.—W. 45° from the vertical.

S. Aulad Hosein, Extra Assistant Superintendent, G. T. Survey Office.—Time 6 hrs. 10 mins. 30 secs. by standard turret clock of G. T. Survey, which stopped at this hour. Direction N. W.—S. E. Sound like a distant train at full speed. The following clocks were stopped :—

Turret clock—whose pendulum swings		290° 15′
Standard sidereal clock	do.	1° 0′
Mean time clock	do.	354° 30′

The rates of these clocks were also changed by the earthquake. Tank water moved N. W.—S. E.

Mr. R. Willoughby-Foster, Solar Photographer to Government, G. T. Survey of India.—Time 6-12 by an excellent watch in time with the turret clock. Duration of shock 50 to 55 secs. Direction S. W.—N. E. by position of photohelio telescope. Sound as of a very strong wind. (Note by Mr. R. R. Simpson): "The telescope is supported centrally, and can move in any direction. Before the earthquake the object end was N. 80° W. of the central pillar. Afterwards it was found N. 25° E. of the pillar, and it had moved upwards vertically until arrested by touching the wall of the dome." Mr. Foster was in his bathroom standing. He felt the wash-hand table sway and water jump about. Tooth water tumbler overturned.. Water from tub (full) overflowed and wet his feet. He felt "groggy" in the legs and suffered nausea. Photo. chemicals in observatory on N. shelves were thrown down and broken. Those on E. not affected. Photos of the sun taken on that day give a good idea as to how unsteady the earth was.

Earthquake Forms from Nalapani Camp, 2 miles E. of Dehra Dun :—

Mr. F. H. Grant, Survey Training School. He was under canvas. There were 2 distinct shocks with one minute interval. The first was the more severe. There were vibrations for several minutes afterwards. Sound like rushing wind through trees, which accompanied the earthquake. Water in bath tub thrown out in all directions but particularly E.—W. There were no preliminary tremors noted.

Mr. B. R. Hughes, Survey of India.—One main shock. Direction about N.—S. lasting nearly a minute. A rumbling sound like thunder accompanied by as it

seemed a high wind during the main shock. He first thought it was a dog under the bed. When he got up he could not stand without taking hold of the centre pole of the tent, which was shaking as if in an awful dust storm. Bottle of kerosine oil on ground fell to the E. Bottle of Eno's Fruit Salt half full fell W. on the table. Pint bottle of whisky on table did not fall. Banks of streams displayed small landslips.

Abul Aziz, Probationary Sub-Asst., Survey Training School.—One main shock N. E.—S.W. Sound like train half a mile away, half a minute before the main shock. Bottles fell: Eno's Fruit Salt, Propert's A. and N. Polish, both from the W. corner of the table. A fissure at foot of the ridge about 1 ft. wide and running N.—S., its length being about 2 chains. One bucket about ¾ full overturned, another was half emptied but not overturned.

A. G. Harrington, Survey Training School.—One principal shock E.—W. A pair of Indian clubs in standing position with bases 6 in. diameter and weighing 6 lbs. each fell down in E. direction. Earth fissure along flat-topped ridge and running N. E. with the ridge. Fissure 4 in. wide.

Rajpur.

This town lies at the foot of the Mussoorie ridge close to the main-boundary fault which is, however, generally hidden by sub-recent debris fans and alluvium. Mr. Simpson's account is as follows:—The European quarter is to the south, and is built on a gentle slope. It has suffered very slightly. The native quarter is chiefly a long stragglling street running up a steeply inclined ridge between two deep ravines. Much damage has been done in this portion of the town. Some few buildings are said to be founded on rock, a soft shale, but in most cases the alluvial deposits have not been pierced.

Mr. Chapman's godown.

This is the only building seriously damaged in the European quarter. It is aligned E.—W., and is built of dry stone walling. The eastern wall contained a large brick arch, which fell outwards to the east. The ridge pole is supported on four pairs of stone pillars, all of which are irregularly fractured.

The bazar.

E.—W. wall of small house fell to south. In the next house a wall in the same direction displays a strong crack hading W. at 25°. A parallel wall fell to the south.

Gobind Bania's house was considerably wrecked. In it walls running N.—S. show horizontal cracks and cracks hading S. from 10° to 45°.

The verandahs of many houses have been separated from the main structures. The line of separation approximating to N.—S.

In Hussein Bux's house the principal cracks are in walls running N. 30° W., the hade of cracks being to S. at 0° and 25°. Large portions of a wall enclosing the roof fell outwards from the north and west fronts.

Ajab Pershad's house is fissured in all directions, the principal cracks occurring in N.—S. walls. One of the gate-pillars, measuring 22″×22″×8′ fell to due west.

Mitan Lal's house, like most of the buildings in Rajpur, is a double-story brick erection. In the upper story the south and east fronts have fallen out. The chief cracks are in walls running N. 20° E., and hade S. at 30°.

The minaret of a mosque fell to S. 85° E. The broken portion is 11′ 6″ long, and is an octagonal prism with faces 13″ wide. It fell from a height of 12 feet, and the fractured end lies 8′ 6″ from the base. As the base of the mosque is stepped, the minaret probably slipped down some distance after falling.

From the evidence of fallen and cracked walls the chief direction of motion was from north to south, or in the same direction as the slope of the ground. Of objects falling freely, however, a minaret fell to S. 85° E., and a gate-post to due west.

There is no reliable evidence from Rajpur as to time of the shock, and no earthquake forms have been received.

Mussoorie.

Between Rajpur and Mussoorie the hillsides are composed of much crushed slates and limestone. They rise steeply and culminate in the E.—W. Mussoorie-Landour ridge at an elevation of about 7,000—8,000 ft. Mr. Simpson's report continues as follows:—

Foundations, structural materials, etc.

Most of the buildings in the station are founded on limestone. This rock is usually found lying at high angles. It is frequently much shattered and contains numerous veins of white calcite. It is often soft, and argil-

laceous, and contains shaly bands. In many places it is covered by a considerable thickness of calcareous tufa.

Practically all the houses are constructed of roughly-dressed blocks of the limestone set in a mortar composed of one part of burnt lime to two or three parts of limestone gravel, locally known as "budgery." Carefully prepared this is an excellent binding material, but in many cases no care is taken to clean the "budgery" from intermixed dirt, and in such cases the product has little coherence. A peculiar characteristic of this cement is that should snow lie on it for a few hours it subsequently crumbles to pieces, probably owing to the freezing of water within its pores. During the winter it is customary to cover all exposed cement with straw as a precaution against destruction.

Savoy Hotel.

There are four large two-story rectangular buildings with round towers at the corners. The effect of the earthquake has been to wreck the buildings almost completely. The towers were overthrown and many portions of the walls collapsed. The reasons for this are four-fold:—1st, the foundations are probably not secure, the rock is very soft and much shattered, whilst the steep slope at the top of which the buildings are erected is largely supported by retaining walls. 2nd, the building material is very poor, much of it being of a calcareous tufaceous nature. 3rd, the construction is bad, the interior of the walls being of rubbly material, whilst there is little or no appearance of bonding. 4th, the corner towers are a source of weakness, for their walls were not properly tied to the main structure. The principal damage is in walls running approximately E.—W., whilst bay windows facing east or west have been separated from the walls by cracks running N.—S.

In addition to Mr. Simpson's account quoted above, Mr. K. A. K. Hallowes also made a minute examination of the Savoy Hotel in which he confirmed the above conclusions. His sketch of one of the hotel buildings is reproduced (pl. 21), but, considering the style of the building, no object will be gained by recording the long lists made of positions and directions of cracks in the walls. For the assurance of visitors it may be added that the upper stories have since

been pulled down and rebuilt, and the lower stories extensively repaired.

Mr. Simpson continues:—

The Convent.

This is a large single-story building constructed of rough limestone blocks with brick bonding. It faces S. 10° E. It is significant that that portion of the building built on rock is practically uninjured; whilst the major portion, said to be founded on clay, but apparently chiefly on "made ground," is little better than a ruin, and will require to be entirely rebuilt (see pl. 16, fig. 1). In several walls running E.—W. the principal cracks hade east at angles of from 0° to 30°, but in the most pronounced case—the children's dormitory—the hade is to west at angles of 28° and 34°. In two cases strong, horizontal cracks traverse E.—W. walls. In walls at right angles the hade is usually N. at 45°. Floor cracks approximate to N.—S. in direction, a well pronounced floor crack running S. 15° E. and standing open about ¼ inch. All the verandah pillars are injured, those on the north and east fronts being cracked right through at the base. The entrance pillars fell east, whilst the pillars of a balustrade fell to west. A two-story belfry fell in all directions. The principal direction of motion was from west to east.

With reference to this building Mr. Hallowes remarks that it may be that the great damage done to the front with its line of pillars is more due to subsidence of the made ground than to the actual shock: inasmuch as a little further down the hill the school of the convent, which is built in the same style but almost entirely on a ledge of rock, has suffered very slightly indeed. His view of the building from the north is reproduced (pl. 22).

Mr. Simpson's account proceeds:—

Municipal bullock depôt.

This is a two-story building facing N. 7° S. W. It was severely injured, the upper-story having been removed prior to my examination. The lower story shows numerous structural cracks. The end walls fell outwards. A horizontal crack has developed in an E.—W. wall, the cracks in walls in that direction usually hade E. at 40°. The most important

H

fissure is, in places, one inch wide, and runs through floors and walls alike, coursing N. 50° E.

Direction of principal motion N.W.—S.E.

Charleville Hotel.

This group of buildings is constructed partly of limestone blocks, and partly of brick. Only one of the buildings has suffered severely. This is a brick erection of three stories, and is aligned N. 55° W.—S. 55° E. At the S. E. end there are square flanking towers, the walls of which make an angle of 135° with the walls of the main structure. Every face of these towers is badly fractured in all stories except the highest, which is a brick-filled frame of wood, and probably yielded to the shock. The cracks are almost entirely structural as shown in sketch (fig. 27).

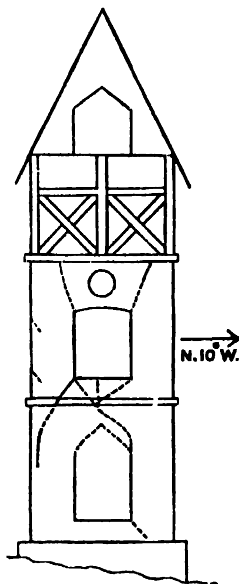


FIG. 27.

The most important cracks in the main building run N.W.—S.E., but chiefly follow lines of weakness such as bay windows. In a wing running N. 35° E. rounded portions of the walls are fractured vertically on lines joining window openings, and a few corners of rooms are slightly cracked. In a wall running N. 55° W. a crack hades S. E. at 30°,

whilst in walls at right angles the hade of cracks is 0° and 20° to S.W. In the roof of a verandah cracks are displayed running N. 35° E., and also at right angles to this direction.

Misty Cottage.

Faces S. 5° W. Central room displays horizontal crack running through all the walls along the line of a cornice about 12 inches below the ceiling. The corners of all rooms have opened out. Cracks are chiefly vertical, and are most pronounced in N.—S. walls.

Bracelley Cottage.

Faces due west. The worst cracks are to be seen in N.—S. walls. Two chimneys are cracked round the base, and that on the east front fell due east towards the slope of the roof.

St. Alban.

Faces N. E. A portion of the north-west face fell outwards. Walls running N.E. display numerous fractures, chiefly on structural lines. (See pl. 16, fig. 2.) Several houses in this neighbourhood were wrecked and are now being demolished. In every case the material and construction are poor.

Rink.

This is largely a wooden erection, and such parts are uninjured. The eastern portion is of brick, and of this, arches in walls running N.—S. are badly cracked.

Christ's Church.

This is a strongly built erection of stone and lime oriented S. 60° E. The only damage is to the tower, on the N. E. face of which a waving, vertical crack runs from top to bottom. On the opposite face a slight crack is to be seen at the crown of a window arch, whilst an interior crack occurs over a doorway.

In the Parsonage a slight floor crack courses N. W., a few slight corner cracks have developed, and the roof has been severely jarred.

New R. C. Chapel.

This building is aligned N. 20° W. It is under construction. At the time of the quake the skeleton of the building was complete. The greatest damage is on the north gable, a portion of which fell to the south and the foundations of which are said to have sunk from 4 to 9 inches. The face wall of the eastern transept fell chiefly to the east. The steel girders forming the roof

skeleton were wrenched to the west, the movement finding play at a joint. The longer walls, coursing N.—S., are slightly bulged to the east.

Principal direction of movement W.—E.

Civil Hospital. This is a large single story building aligned N. E. The south-west verandah is wrecked, and the building shows a number of structural cracks, the most pronounced running N.E.

Landour bazar. The houses on the south side are built on made ground held by retaining walls. Prior to the earthquake these buildings leaned towards the cliff, and this is said to have been greatly accentuated at the time of the quake. The displacement from the vertical is now 9°. Yawning cracks have developed, and the buildings are in a highly dangerous condition.

Pleasure View and the Club House, Happy Valley. These buildings display a number of structural cracks, the most pronounced traversing a godown wall running N. 70° W.

Kildare and Lyndhurst. Both these houses have been seriously damaged. Every wall is fractured. The evidences of motion are so contradictory that details of the damage are omitted. In godowns close by walls running N.W.—S.E. show cracks hading N. W. at 0° to 30°.

Niyadmal Bania's house. In this house walls running N.—S. show strong vertical cracks, chiefly structural.

Erindale. A two-story bungalow facing N. 50° W. On the S. E. face a crack hades N.E. at 25°. On the S.W. face the cracks are either vertical or hade N.W. at angles up to 45°. In the interior there is much damage chiefly on structural lines.

Lynndale. This house is a large single-story building facing S. 10° W., and built on an E.—W. spur. The most conspicuous damage is to the north face, which has moved out to the north, the displacement near the ceiling being ⅓ inch. A slight ground crack outside courses E.—W. and is parallel to the edge of the slope. The water in a tank was thrown out on a line S. 75° W.—N. 75° E. The edges of this tank show a crack coursing S. 80° E.

Mackinnon's brewery.

It is a remarkable fact that these buildings, including a brick chimney 105 feet in height, are quite uninjured. The material and workmanship are good. Mr. Philip Mackinnon, a careful observer, informed me that at the time of the earthquake the springs near the brewery sustained an increase of water of from 25 to 30 per cent., and that this increase has been maintained. The same observer states that a similar increase took place in the quantity of water in the Dehra Dun canals. (See also p. 348.)

Kandi Lodge.

This is a single story bungalow standing on a N.—S. spur and facing due south. The east face has moved a full inch at the top outwards. Other walls running in this direction display cracks chiefly vertical. In a wall coursing E.—W. a portion, 3 feet wide by 16 feet high, fell towards the north. In several parallel walls the cracks hade west at 20°. A ground crack running N.W. is parallel to the top of the slope, and probably follows the inner edge of a retaining wall.

The Abbey School.

Faces N. 20° W. The chief damage is to the north front which has moved outwards from one to three inches. A strong crack, coursing N.—S., separates the verandah from the house, and on the south front a bay window is detached along an E.—W. line. N.—S. walls are strongly fractured vertically.

A few ornaments on shelves coursing E.—W. fell to N. and S. Pictures on N.—S. walls were knocked askew, the movement being to the north through an angle of 20°. Pictures on walls at right angles were undisturbed. Beds on castors moved N.—S.

A pendulum clock hanging on an E.—W. wall was stopped. Direction of principal motion N.—S.

In the garden stands an octagonal-shaped summer-house built of brick. Width of face is 12 feet. Cracks on the N. E. and S.W. faces hade S. E. at 10°. On the S. E. face the two cracks are vertical, and on the N. W. the hade is 10° to S. W. Inside the building the contents of a bookcase running N. 40° W. were thrown outwards to S. W. Ornaments on a mantelpiece at right angles were unmoved.

In godowns near by an end wall coursing N. W.—S. E. and two parallel partition walls were thrown down to N. E. Walls at right angles were fractured vertically.

Direction of principal motion S. W.—N. E.

Hazelbrae. This is a poorly-built single-story bungalow facing N. E. It has been completely wrecked. Parts of the N. E. and S. W. faces fell outwards causing the roof to fall. The S. E. face is undamaged, but the N. W. face displays a vertical fracture.

Direction of principal motion S. W.—N. E.

Near by, a retaining wall, 20′ × 80′ × 15″, facing S. 20° W. fell outwards.

Cemetery.. Retaining walls fell outwards in several places, chiefly to N. but occasionally to E.

An ornament on the top of Major Wheatley's tomb fell to N. 65° E. A sandstone cross, erected to the memory of Henry Earl Read, was displaced and now leans against the enclosing railing at a point S. 20° E. of its original position (fig. 28).

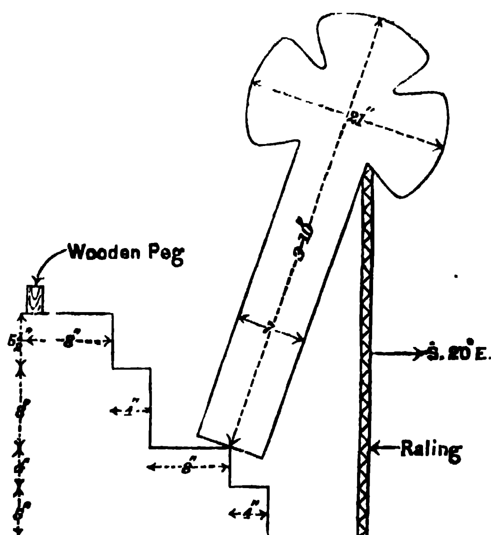


FIG. 28.

Kacheri.

This is a large, rectangular building with three stories along the front and two at the back or towards the rise. It faces S. 22° W. The greatest damage is to the south verandah which has moved out at the top about ¾ inch. The south main wall has moved in the same direction about ⅛ inch, and also shows faint horizontal cracks. On the east and west faces there are many faint cracks hading north at angles of 0°, 1°, 3°, 5°, 10°, 20°, and 30°. In the interior the walls coursing N.—S. display cracks either vertical or hading N. at a low angle.

No damage was done to the treasury and the European lock-up, but the native lock-up and the police office display very slight cracks running chiefly E.—W.

General direction of motion N.—S.

Grey Castle.

Coolie barracks near this house have been damaged. They face the hill slope and to N. 25° E. The north face has partially fallen outwards. An interior partition wall running E.—W. fell to the south. An end wall displays cracks hading N. at 20°.

General direction of motion N.—S.

Evelyn Hall.

Faces S. 75 E. The front verandah is separate d from the main building. In a detached building a wall coursing N. 20° E. displays a crack hading S. at 10°.

An annexe faces N. and walls running N.—S. are cracked, the chief fracture hading N. at 2°.

Hazlemere.

A wall coursing N. 5° E. is fractured vertically, another crack, however, hades N. at 10°. A crack in a wall at right angles hades E. at 20°.

The kitchen is a separate building facing N. 18° E. A wall in that direction shows irregular branching cracks approximating to the vertical. The walls at right angles display a strong crack hading N. at 10°, and a lesser fracture hading N. at 70°.

Chateau Kaparthala.

It is worthy of mention that this, probably the largest and most substantial building in Mussoorie, has escaped without a trace of damage. It is a two-story, oblong erection aligned N. 15° W.—S. 15° E. Towers at the corners are about 50 ft. high, and carry conical roofs rising about 20′ further. The building is constructed of hard, roughly-dressed limestone with layers, 2 feet apart, of brickwork 10″ thick.

Bellevue.

This is a large single-story bungalow aligned N. 55° W. Walls in that direction are fractured vertically in a few places. The chief cracks run through the building on a line N. 35° W.—S. 35° E.

Gowrie House.

This is a two-story, stone built house facing north and south. It is very badly damaged, the chief injury being cracks in E.—W. walls hading E. at angles of from 0° to 35°.

Government Telegraph Office.

A few slight cracks are to be seen in N.—S. walls only.

General Post Office.

Considerable damage was done. A portion of a wall fell to S. 40° E. The worst cracks are in walls coursing N. E.—S. W.

Mr. F. Bristoe's shop.

During the great shock a large number of bottles fell towards the north. By the shock occurring near midnight of the same day the same bottles fell towards the west.

Turret clock. Methodist Church.

Mr. Hallowes has described the interesting case of the clock on the Methodist Church, Mussoorie. This clock which was fully wound up, had stopped on April 3rd (the day before the earthquake) owing to the striking gear getting out of order, but on the morning of the 4th it was found to be going, having been restarted by the earthquake. As the pendulum was only free to swing in a slit running N. 50° W. which was very nearly at right angles to the long axis of the building as a whole it seems likely that

the building rocked as a whole about that axis and imparted the necessary swing to the pendulum. (See fig. 29.)

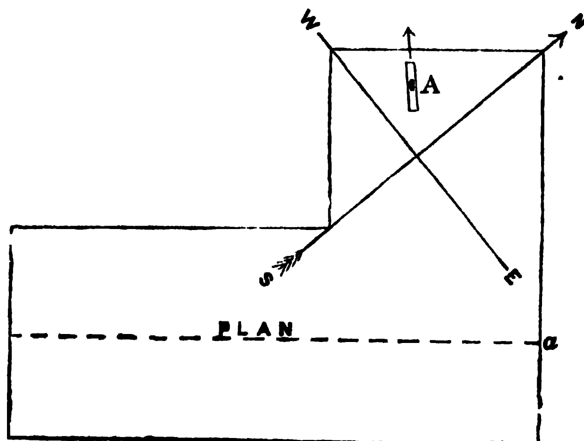


FIG. 29.—A = slit in which pendulum swung.

Mr. Simpson's account continues :—

Fissures and landslips.

On or near the road from Dehra Dun to Mussoorie *viâ* Rajpur there appear to be no ground fissures or recent landslips. On the southern slope of the Mussoorie ridge, and some distance west of the road, two small landslips are said to have occurred at points where slips are wont to occur annually during or after the rainy season.

The only landslip of importance of which information has been received took place near the Kampti falls, about 9 miles west of Mussoorie, and on the northern slope of the ridge. This locality was visited by Mr. Hallowes, who has described it as having occurred along the line of a steeply inclined fissure partly infilled with stalagmite. A few other minor slips on the Mussoorie-Chakrata road were reported by Captain A. Anderson, Public Works Department, Executive Engineer, Dehra Dun District.

In Mussoorie itself several fissures were made in the roads by the shock. They were filled up immediately afterwards, and nothing was to be seen at the time of my visit. Their position and extent was,

however, pointed out to me by Mr. Keatinge, the Secretary to the Municipality. In no case was vertical displacement involved.

(1) Crack on the Mall in front of Messrs. Bevan's music shop. Said to have followed the centre of the road for 100 feet on a course S. 60° E. The rock hereabouts is far from homogeneous. In the excavation for the foundations of the houses numerous clay-filled fissures are said to have been met with.

(2) On the Camel's Back road, the small terraced promontory known as Scandal Point displays a number of cracks. This terrace is largely of "made ground." The fissures are only to be found in the "filling," and do not traverse the rock.

(3) On the north of Camel's Hump a crack is said to have opened out about 4 feet from the outer edge of the road, and to have run parallel with the edge for 125 feet on a course N. 85° W. The width of this crack was about 2 inches, and the depth exceeded three feet six inches.

(4) On the Mall, just above "The Dingo," a crack, 50 feet in length, 3 inches wide, and exceeding 3½ feet in depth, opened up on a line approximately parallel to the edge of the road. Owing to there being a curve at this point the distance of the crack from the edge of the road varies from 4 to 12 feet. The road is flanked by a retaining wall perhaps 12 feet wide.

(5) On the Mall below the Kacheri. This crack is said to have been 150 feet long and half-an-inch wide. It ran along the road about 20 feet from the edge, and 6 feet from the wall of the cutting.

(6) The cracks in Landour bazar have already been referred to. They are several in number and from 0″ to 3″ wide. They do not pass through the road, and are probably confined to "made ground" held by retaining walls.

In nearly every case these fissures run parallel to the edge of the road cuttings in a direction approximately east and west. They, however, afford little evidence as to the general direction of the earthwaves.

ne records.

These vary from 6-6 to 6-15 A.M. The most reliable are :—

(1) Clock in Postmaster's house which stopped at 6-10 A.M.

(2) Clock in the Government Telegraph office which stopped at 6-10 A.M. Both clocks are said to have been correct at the time.

Character and direction of shock: sound phenomena.

All accounts agree that the shock was a violent one. Several observers noticed three distinct shocks with intervals of between two or three seconds, the whole lasting from one to two minutes. One eye-witness records preliminary tremors lasting 15-20 seconds. Mr. P. W. Mackinnon says :—" The first shock continued for two minutes. After an interval of 10 minutes another shock less severe occurred, followed by several slight shocks up to 8 A.M.; seven shocks in all . . . . There were a great number of tremulous vibrations in the intervals between shocks up to 8 A.M."

Nearly all observers consider that the earthquake motion was from south to north or *vice versâ.* The evidence of buildings is very contradictory, but the worst-damaged structures apparently moved in a W.—E. direction. The water in tanks was observed to move both E.—W. and N.—S. The direction of swing was undoubtedly largely influenced by topographical features, ridges vibrating along a line at right angles to their axes. The general direction of the Mussoorie ridge is N. 75° W.—S. 75° E. Many people noticed moaning, rumbling or rattling noises just before and accompanying the chief shock.

Mr. Fisher, a local watchmaker, hung up a pendulum at 2 P.M. on the 4th April. During the after-shocks, this pendulum swung freely. Its direction of swing is N. 38° W.—S. 38° E.

Landour.

Foundations and structural materials.

The lower portion of the Landour ridge on the west is composed of a continuation of the limestone upon which Mussoorie is built. The upper part consists of

thinly-bedded, buff to brown or dull purple shale. This rock is often friable. It is frequently siliceous, and contains thick bands of white quartzite, and occasionally steel-grey sandstone.

Most of the buildings are constructed of stone, usually the same rock as the building is founded upon. Lime and stone mortar is almost universal.

Many retaining walls have been thrown outwards, whilst others are bulged irregularly.

No. 2 barrack. All walls show severe fracturing in both horizontal and vertical directions. A wall coursing N. 60° E. fell partially to N. A wall at right angles moved out ¼ inch at the top to west.

No. 11 barrack. The longer walls coursing N. 35° W. are cracked horizontally from end to end, and are bulged to E. Walls at right angles are fractured vertically.

In a native dwelling near by, a wall facing N. E. has fallen in that direction.

No. 7 barrack. Is aligned N. W. Two chimneys 20 inches square and 7 feet high are fractured at the base. That at the western corner leans to N.E. The building is fractured structurally.

No. 8 barrack. Oriented N. 70° E. The main walls facing N. and S. have fallen outwards. Walls at right angles display many irregular and some vertical cracks.

Guard-room No. 13. A N.—S. wall fell out to W. Another wall in the same direction moved out ½" to W.

District staff office. A wall coursing N. 30° W. has moved slightly to west.

Canteen. A wing wall coursing N. 50° E. has separated ¼ inch from wall at right angles.

All these buildings are poorly constructed. The better built military structures such as the gymnasium, a lofty building with walls 3 feet thick, are uninjured.

St. Paul's Church.

This is a small, substantial building with a low belfry. A buttress on the north face is irregularly cracked, and a few slight vertical cracks are to be seen on the west front. The interior is undamaged. The arches on the west face are slightly cracked.

Mr. T. A. Rust's shop.

A wall facing S. 50° E. displays cracks hading S. W. at angles of from 2° to 12°.

R. C. Chapel.

Aligned N. 55° E. The limited amount of damage indicates motion along the axis of the building.

A boundary pillar, near by, fell partially to S. 40° W. and in the direction of the slope of the ground.

Mullingar, The Philander Smith Institute.

This is a two-story, rectangular building aligned S. 60° W. All corners have opened out slightly, particularly those on the S. W. All walls show fractures. Those coursing N. W.—S. E. show most indication of injury, the fractures hading 0° or slightly to N. W. In walls at right angles the hade is often to S. W. at from 5° to 25°.

Prospect Point.

This house stands on an E.—W. ridge of quartzite, 50 feet wide. It is uninjured, although massive retaining walls on both sides fell outwards to N. and S.

A looking-glass standing on a bracket fixed to an E.—W. wall was thrown down to N. 15° W. Having a height of 1′ 6″ it was projected 3′ 6″ in a N. 15° W. direction.

Hospital.

The compound wall built on a retaining wall on edge of slope to S. W. leans at an angle of 7° in the same direction. In the Assistant Surgeon's bungalow the chief fractures run S. 75 E.—N. 75° W. In the kitchen walls running N.—S. are strongly fractured, one crack being 2 inches wide.

Mrs. Bachmann's house.

Is built on an E.—W. ridge. A verandah facing N. 30° E. has partially subsided down the slope. Walls coursing N.—S. are fractured.

Elcott Lodge.

This building was badly cracked prior to the earthquake. The principal fractures course N. 80° E. or paralled to the axis of the ridge. The only effect of the quake, as shown by tell-tales fastened across the cracks, has been to close some of the cracks and open others.

Cemetery.

A plant-pot standing on a wall fell over, at right angles to wall, to S. 35° W.

A cross erected to the memory of Curtis Martin fell to N. 18° W. (See fig. 30.)

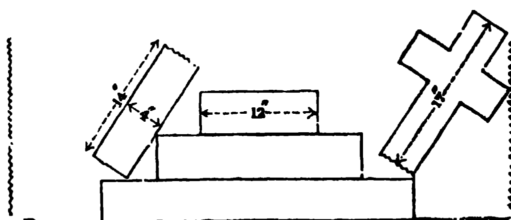


FIG. 30.—Scale $\frac{1}{20}$.

In a stone-shed, walls facing N. W. and S. W. have partially fallen outwards.

Childers Lodge.

The four corners of the entrance hall have opened out. All the walls are fractured, particularly those coursing N. W.—S. E.

In an outhouse the walls facing N. W. and S. E. have fallen outwards. The N. E. face bulges outwards.

In the kitchen, walls facing N. 60° E. bulge in that direction.

In a godown the walls running N. 15° E. display strong fractures the hade of which is to N. at 5° to 20°. Two partition walls in this direction have fallen chiefly to E. The north face has fallen outwards.

Rockville Cottage.

This is a single-story building aligned N. E.—S. W. It is built on hard quartzite, and is badly constructed of irregular blocks of shale and quartzite with mud mortar. It is now a complete ruin. On the N. W. face the verandah has collapsed and a portion of the main wall has fallen outwards. Wing walls coursing N. W.—S. E. have separated 1½ inches from walls at right angles. Strong cracks run through the building on a N. E.—S. W. course, the hade being usually to N. E. at 20°.

In the coolie lines partition walls running N. 60° E. fell, chiefly to S. 30° E.

Rockville.

Most of the damage has been repaired. The incidence of the fractures points to motion in a N.—S. line.

Woodstock.

This consists of a number of large two or three-story buildings enclosing a quadrangle. A good deal of general damage has been done to walls and arches in the south and west wings.

Apparent direction of principal motion N.—S.

Abergeldie and Edgehill.

In both of these buildings the corners of rooms are cracked, E.—W. walls have moved out to south, and N.—S. walls display vertical fractures.

Time occurrence of shock.

The most reliable estimate is 6-10 A.M. recorded by Lieutenant H. W. Kettlewell, the Cantonment Magistrate.

Character of shock, etc

The intensity of the shock was probably about equal to that at Mussoorie and Dehra Dun, or between 8 and 9 of the Rossi-Forel scale. Here, as at the above-mentioned places, well-built structures on good foundations, such as the newer barracks, Rokeby, the Kellog Institute, etc., escaped either entirely or sustained merely trifling injury.

Several persons noticed tremors lasting from 15 to 20 seconds both before and after the chief shock. Estimates of the duration of the latter vary from 15 to 60 seconds. One observer records the occurrence of three distinct minor shocks within 5 minutes of the main shock.

Lieutenant H. W. Kettlewell considers that the disturbance consisted of violent lateral vibrations estimated at four to the second. This view is supported by Major E. W. Allum.

The chief direction of motion was apparently in a N. E.—S. W. direction or at right angles to the general trend of the Landour ridge. There is, however, a large amount of evidence of motion in other directions, and this can easily be understood if the impressions of the Reverend . S. Woodside are true ones. That observer states :—" The shock

seemed to be met by a counter-shock, for I first was sent towards the east side of the room, then south, and west, and all round, for quite a minute."

As at Mussoorie, many people heard sounds either before or during the quake. They are likened to that produced by a storm or a high wind, whilst some heard a roaring or rattling noise.

Earthquake Forms—Mussoorie and Landour.

(The same remarks apply here as in the case of the Dehra Dun Earthquake Forms, see page 93. All sleepers were awakened.)

Mr. W. J. Goodman, Sub-Engineer, Military Works, Landour.—There were first tremulous vibrations for 15 seconds. Second, two severe shocks with 15 minutes interval (*sic.*). Third, end vibrations for 15 to 20 seconds. Direction N. E.—S. W. by displacement of roof timbers. Sound like reverberations of a blast coming up from the valleys N. W. of Mussoorie and dying away in that direction. He opened door with difficulty. Saw natives escaping down the "khud" (hill slopes). Bell of St. Paul's began to ring in an undecided sort of way. Iron tank, 4′ by 4′ by 4′ for rain water, threw out water at every two seconds. Water afterwards 1 foot below the rim. *N.B.*—There was a lid. There was a dusty haze in the direction of Mussoorie. Earth fissures behind depôt parade ground. The earthquake emphasised the difference between good and bad buildings.

Mr. W. Beaford, late of the Forest Department.—Direction N. E.—S. W. about. Standing and walking was difficult (indoors). A dinner waggon was thrown S. A large mirror was thrown off wall 4 feet to the N. Bottles and vases overthrown. Earth fissures near Prospect Point, varying in direction between E.—W. and N. E.—S. W.

Rev. J. S. Woodside, American Presbyterian Mission.—There was 1st a slight quivering, 2nd a shock, from N. W. (he thinks) met by a counter-shock, because he was first sent to the E. side of the room and then S. and W. and finally all around for 1 minute. Vase on N. side of room fell inwards a little W. of S. Water jug did not fall. The rush of sound lost in the creaking of timbers and jarring of doors. During 56 years in India, though he had felt many earthquakes, none were so severe as this.

Lieutenant H. W. Kettlewell, Station Staff Officer and Cantonment Magistrate, Landour.—Time 6-10 A.M. by new watch exact with telegraph time. First trem. vibrations for 3 or 4 seconds, then 2 seconds interval; 2nd a violent shock, duration 15 seconds. Direction S. E.—N. W. in the form of lateral vibrations 4 to a second. The sound a distinct rumbling accompanying the main shock. The house rocked violently and it was difficult to stand. Bottle of spirits fell N. E. Two silver cups fell E. S. E.

Mr. E. A. Wainright, Survey of India at "Silverton," Mussoorie.—First 2 slight shocks N.—S., second the principal shock duration 20 seconds, 3rd vibration for 5 minutes, 4th a great shock of 15 to 20 seconds duration. Direction N. W.—S. E. Music stand fell S. E. Water and milk thrown from jugs. The sound a continuous rumble during the main shock. The motion seemed both vertical and horizontal. Lamps swung N.—S. A few slight earth fissures and surface wall cracks.

Mr. M. J. Blong, Telegraph Master, Mussoorie.—Time 6-11 A.M. (Madras time) by reliable telegraph clock. Sound like sudden gust of wind. There was first a severe shaking, then a slight pause which lasted 1 minute, then the upheaval. There was a feeling of sea-sickness. Table lamp overturned on table, bottles on almirah knocked down, cracks in house straight up and down and over doors and windows, and only in N.—S. walls.

Revd. L. Kiugh, Chaplain, H. M. I. G. at the "Parsonage," Mussoorie.—There were 2 main shocks, the heaviest first, N. by W.—S. by E., then an interval of about 15 seconds then slighter shocks W.—E. There was a deep rumbling during the main shock and before the second big one. The following were thrown down : small bookcase parallel to and touching N.—S. wall, a wall lamp on nail in the same, some china on stand near by, pictures out of level, vase 12 inches high thrown forward to the E., water from iron buckets spilled in a circle except for a slight break of continuity on the N. or N. W. side.

Mr. Y. A. Keatinge, Secy. and Supdt., Municipal Board of Mussoorie.—Time 6-10 by watch constantly compared with telegraph time. 1st a rumbling sound, then 3 shocks with intervals of a few seconds. Direction S.—N. The Municipal hall shook up and down. He was hardly able to stand. Building swayed N.—S.

Mr. N. A. R. Chambers, C.E., Mussoorie, and Engineer in charge of the R. C. Cathedral.—He was pushed N.N.W.—S.S.E. and unable to keep his balance on the ground of the compound, and so had to lie down for 20 seconds. A cup full of sugar upset S. A heavy flat inkstand shot off the table to N. He inspected 24 houses and noticed that walls running N.—S. were cracked from top to bottom. In the R. C. Church he noticed a parting between one of the pillars and the capital with a horizontal movement of $\frac{3}{4}$ to 1 inch away from the centre of the pillar. A twisting motion was also recorded in the case of an iron safe which had rotated contrary to the hands of a watch about 2 or 3 inches ; whilst the same was noticed in the case of a chimney stack.

Mr. P. W. Mackinnon, "Lyndale," Mussoorie.—Time 6-14 A.M. by watch compared at 10 same day with telegraph time. Duration of main shock 2 minutes. Direction N.E.—S.W. A moaning sound before and passing into the main shock. House and trees swayed to and fro. Distinct undulation of the ground under foot. Water of tank thrown out N.E.—S.W. Increase of over 25 per cent. in water in springs above house (see p. 348).

Mr. U. A. Mackinnon, "Kandi Lodge," Mussoorie.- There were 9 or 10 shocks. A loose wall fell to N. Rock slides W. of Kandi Lodge on Benog. The ravine was full of fine dust. He stumbled repeatedly running out of the house.

Mr. L. J. Evans, Civil Engineer, "Dumbarnie," Mussoorie.—Shock believed to be continuous but varying in intensity. Direction N.—S. but N. 20° E. by swaying lamp. He first thought it was a dog under the bed. When standing up the rapidity of the shocks reminded him of the strokes of a piston of steam engine. Each stroke would have made him fall but for the next which righted him. There were about 150 or 180 to the minute as tested by a watch afterwards. Enormous trees swayed. Room with boarded floor running E.—W. humped up in the middle giving a slope N.—S. As a general rule long walls running N.—S. have suffered least. Cross walls have been very much battered. Long walls running E.—W. have been cracked at intervals of 5 or 6 feet. Short walls N.—S. have been drawn apart at points of least resistance, *i.e.*, springings of door, arches, etc. Alligator skin pattern cracks in plaster of rubble masonry walls.

Miss Hope, "Clairville," Mussoorie.—At some time during the night or early morning she was awakened by barking of dogs in her room. She heard creakings (see foreshocks, p. 355). Of the earthquake itself there were 1st tremulous vibrations of door, 2nd as she was standing she felt as if she had been taken by the shoulders and shaken violently 3 or 4 times. Flower vases on dining room table overturned. Bottle thrown off chest-of-drawers. Camp folding looking-glass thrown off the mantelpiece, frame broken, but not the glass.

Mr. W. C. Horst, Head Master, "The Abbey," Junior Mussoorie School. —Two distinct severe shocks with an interval of 2 or 3 seconds, the second being the more intense. Direction N.—S. He had to hold on to things to steady himself walking. Whole room rocked violently N.—S. Two heavy iron bedsteads on castors moved back and forth leaving an impression about 2 inches long on the carpet. Two brass vases fell S. Two book cases at walls running N. W.—S. E., one thrown down. Books thrown out. Picture frames displaced 20 inches with horizontal. Pendulum clock stopped.

Hardwar.

Hardwar, and the towns which follow in this description, really lie outside of the Dehra-Mussoorie epicentral tract, but, coming as they do within Mr. Simpson's sphere of description, they are included here for the sake of uniformity. Hardwar lies on the right bank of the Ganges just where it cuts across the range of the Siwaliks. Near this point also the main boundary fault curves sharply to the south just as happens between Guma and Mandi in the Kangra Valley area.

Observations of the time of the chief shock vary from 6-10 to 6-15 A.M. The pendulum clock in the railway telegraph office is said to have stopped at 6-13 A.M.

Time records.

A portion of the town is founded on soft Siwalik sandstone rock. The rest of the buildings and also the civil station are on alluvium.

Construction of buildings, etc.

The principal structural materials employed are well-burnt brick with a lime-sand mortar. As a rule the workmanship is very good.

Hardwar City. Very little damage was done here.

In Baramal's house, arches running N. E. are slightly cracked at the crown.

In Rawaiji's house, a wall running N. 16° E. has moved slightly in a lengthwise direction to S. 16° W., and also displays cracks hading 25°--30° in the same direction.

An archway in the house of the Teri Rajah, running N. 55° E., shows a slight vertical crack about midway between the crown and the spring of the arch.

In the station building a wing wall has moved slightly, in a lengthwise direction, to S. 35° E. Slight waving cracks are to be seen in walls and arches coursing N. 55° E.

Railway buildings.

In the first-class waiting room one of the jack-arches forming the roof is cracked lengthwise on a course N. 35° W. This fracture is connected with cracks in the north and south corners of the room, indicating that the cross-walls have moved in a W.--E. direction.

The assistant stationmaster states that rolling-stock in the station-yard moved about 3 feet along the lines to S. 50° W., and after about three oscillations returned to its first position.

The locomotive shed is aligned N. 50° E.—S. 50° W. Two of the arches coursing in this direction are cracked. The arches at right angles are uninjured.

This building shows a number of fractures, chiefly on structural lines. The principal crack runs right through the building on a N. E.—S. W. course, and before repairs was said to have been about one inch wide.

Municipal bungalow.

Assistant Engineer, Canals, bungalow.

Walls coursing N. 70° W. appear to have moved lengthwise. Water splashed out of a basin to E.

Public Works Department inspection bungalows.

The corners of the rooms are cracked, and walls coursing N. E.—S. W. have moved in a direction at right angles to their plane.

Bhingoda "band."

This is a boom across the Ganges about two miles above Hardwar. It courses N. 75° E., and is composed of wooden crates filled with stone, abutting one against the other. Three of these crates were broken on the down-stream side during the quake. The position of the break can be seen from the sketch (fig. 31), which represents the upper portion of the "band."

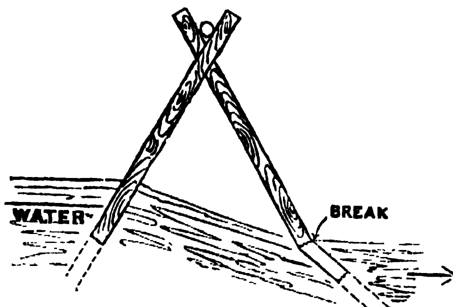


FIG. 31.

Probably the force causing the break is the resultant of the force of the current and the force due to the earthquake impulse.

Mr. Hallowes has described some fissured railway cuttings in Siwalik conglomerate a short distance from Hardwar and three miles from Diowala up the valley.

Intensity, direction of shock, etc.

The intensity of the shock must have been much less than at Dehra Dun. In the city, where temples and lofty buildings are numerous, hardly a trace of damage is to be seen. The intensity was probably between 7 and 8 of the Rossi-Forel scale. Most of the evidence points to movement on a N. E.—S. W. line. The two Europeans in the station at the time consider that the shock came from west to east. Mr. Kavanagh, the

Deputy Superintendent of Police. Saharanpore, who was in Hardwar at the time, writes :—" The shock was continuous for about 35 seconds, *i.e.*, the to and fro movement, commencing with an up and down movement, then from east to west, and ending gradually." Several persons record hearing a rumbling noise, like rolling thunder, during the quake.

Earthquake Forms—Hardwar.

Mothura Prasad Bhalu, Forest Ranger.—First tremulous vibrations, then half minute interval, second the main shock, consisting of two to and fro movements W.—E. The Ganges here runs N.—S. He noticed three big waves 12 feet high whose crests were parallel to the length of the river. Anyone trying to move quickly was thrown to the ground.

Mr. H. Kavanagh, Deputy Superintendent of Police.—First, windows and doors rattled, ground shook as if a railway train was rushing past the house; second, a continuous shock for about 35 seconds. It began with an up and down movement E.—W., and ended gradually. Third, four other shocks, lasting each about 20 seconds. There was a sound as of rolling thunder during the first shock which continued till the end. He was nearly upset by the shock. Felt sick. He saw the chimney of his house shaking violently. Office walls damaged. Canal water lowered one foot.

Mr. B. Darley, Assistant Engineer, Public Works Department.—Time 6-10 by watch checked at railway station the night before. Direction W.—E. by water in basin. Sound was a deep rumble like a falling house (there were no fallen houses within two miles). Very distinctly felt. It was impossible to stand. N.—S. wall rocked to and fro. Cracks in arches in E.—W. walls in two bungalows, which necessitated the arches being rebuilt.

Kankhal.

This town is situated on the Ganges canal about one mile south of Hardwar.

Damage to buildings.

In Bharamal's garden a three-story gateway facing S. 70° W. displays vertical cracks in arches and windows on both front and back faces.

In Bhirin Narayan's garden a four-story gateway facing N. 70° E. is fractured on both front and back faces. A minaret fell to the south.

Several buildings are cracked structurally. In a wall coursing N. 55° W. an old crack has opened out to one inch wide.

In Malraj's house a wall running N. W.—S. E. has moved out at the top one inch to S. W.

In Mangla Khwa's house a wall, 35 feet in height, coursing N. 55° W. displays an instructive fracture hading N. W. at 8°. The width of the fissure increased from one-fourth inch at the ground level to three inches at the top. The wall is a perfectly plane surface without windows or doors.

In a house owned by the Raja of Chakrauli a wall running N. 30° E. shows a crack hading 25° to N. 30° E.

The direction of principal movement was probably N. W.—S. E.

Pathri. Ten miles south of Hardwar. At the time of the quake Mr. W. H. Rushton, Public Works Department, was looking at the Ganges canal, and noticed that the waves caused by the disturbance crossed the canal on a line approximating to N. 15° E.—S. 15° W. Corroborating evidence of this direction of motion was furnished by an embankment wall which by its motion created a gap of eight inches between itself and earth embankment. The walls remain vertical, the earth having been pushed away from it by the motion.

Jowalapur. This is a large town lying some 3½ miles south of Hardwar. A number of buildings have been injured, but few of them severely.

Sertu and Mulla's house.—A wall is cracked vertically. It has moved lengthwise to N. 20° E., the resulting fracture being 2½ inches wide.

Dal Chand's house.—A wall coursing N. 20° E. has moved lengthwise causing a fracture one inch wide. Several walls and arches running parallel are cracked both vertically and with a hade to the south of 45°.

Police outpost.—A wall facing N. 30° W. has fallen outwards.

School.—This is a fair-sized building built of bricks and mud, and aligned N. 20° E. The porch at the south end has separated from the building. The north face of the building has moved outwards fully one inch at the top. There are many other fractures, chiefly structural. The chief motion was in a N.—S. direction.

In Bansi Lal's house a wall running N. 30° E. displays a crack one inch wide, hading N. 30° E. at 48°.

Dispensary.—This building is aligned N. 25° E. The worst cracks run longitudinally through the arched roofs of the main structure and the verandah. The cross partition walls have moved to N 25° E.—S. 25° W., showing that movement also took place at right angles to the main axis of the structure.

In a wall coursing N. 70° W., in Sujaat's house, an old crack hading 15° to W. has widened to 2 to 3 inches.

Pundit Ram Chand's house gives evidence of movement along a line N. 30° E.—S. 30° W.

Most of the evidence points to movement along a line running N. 20°—30° E.—S. 20°—30° W. In two cases, however, the movement was N. 30° W.—S. 30° E and N. 65° W.—S. 65° E.

Rurki.

Rurki not only lies outside the Dehra-Mussoorie epicentral area, but also away from the hills altogether, being situated on the right bank of the Ganges canal and on the alluvial tract of the great Gangetic basin. Its College of Engineering and Canal Workshops make it a centre of some importance. Although on alluvium it is not far from the foot of the Sub-Himalaya, and the not-insignificant damage to buildings and the earth fissures point to this condition having somewhat magnified the local effects of the shock.

Mr. Simpson's narrative continues :—

The railway telegraph clock stopped at 6-15 A.M. According to the time sheet the clock was correct on the previous day. The pendulum swings S. 70° E.

Time records.

The telegraph master noted the time of quake to be 6-8 or 6-9 A.M., using an accurate time-keeping watch corrected daily by the office clock.

Railway buildings.

In the station building the crowns of two arches running S. 70° E. are slightly cracked.

In the officials' quarters a long arched roof coursing N. 70° W.—S. 70° E. is cracked from end to end. Cross-walls have moved at right angles to the main axis of the structure.

In the store a wall facing S. 70° E. has moved outwards from 0 to 2 inches.

In the Assistant Engineer's bungalow bottles were thrown to N. 70° E. Those on shelves at right angles were unmoved. The verandahs are separated from the main buildings by cracks coursing N. 20° E.—S. 20° W.

In the office, walls running N. 60° W. display cracks over windows and doors. A wing wall coursing N. 60° W.—S. 60° E. has moved lengthwise.

Ganges canal workshops.

The water in an overhead tank splashed out to east and west.

In the wood-working shop a wall 30 inches thick and about 35 feet high, facing N. 60° W., has moved out from 0 to ½ inch. The joining of the roof girders has damaged the layers of brick enclosing their ends, causing these layers to project about two inches.

A main wall in the foundry, facing N. 60° W. is cracked horizontally from end to end along a line through the base of the clerestory windows.

A main wall in the machine-shop which courses N. 30° E.—S. 30° W. shows evidence of motion at right angles. In a roof truss a tie-rod coursing S. 60° E. broke away from its connecting bracket.

Mr. Kachener's (?) bungalow.

A portion of a wall and a gate-pillar were thrown down to S. 75° E.

Reformed Presbyterian Church.

The damage is slight, but gives evidence of an E.—W. swing, the direction of orientation of the building.

Telegraph Office.

The clock pendulum swings N.—S. It did not stop during the quake. One of the clerks, who was sitting on a chair, was distinctly jerked to the north.

St. Andrew's Mission Church

This is a large, well-built structure of brick, oriented due E.—W. The wall facing west is slightly bulged to the east near the roof. The western wall, which partly supports the tower, has moved out fully one inch at the roof. The chief injury is to the tower, a tall slender erection at the west end of the

nave. It is about 27 feet high and consists of a spire-capped square lantern carried on four pillars. (Figs. 32 and 33.)

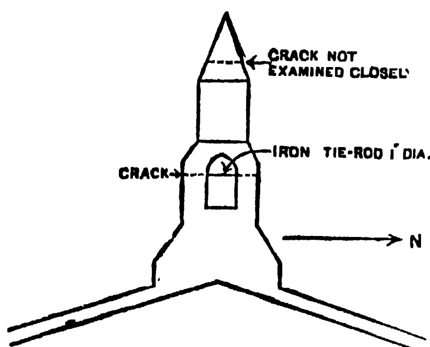


FIG. 32.—Scale 1 inch = 20 feet.

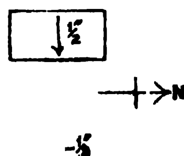


FIG. 33.—Plan of fractured pillars with amount of displacement. Scale 1 inch = 5 feet.

These pillars have been snapped horizontally on a line passing through the spring of the lantern arches, and coinciding with the position of the four one-inch tie-rods. The horizontal displacement of the pillars is as follows :—

S. E.	pillar	moved	½ inch	to N.
N. E.	,,	,,	⅛ ,,	,, S.
N. W.	,,	,,	½ ,,	,, E.
S. W.	,,	,,	slightly	,, S.

The conical spire is also fractured.

St. John's Church.

Oriented E.—W. The west face has moved slightly outwards. The arch in this wall is cracked vertically, as also is the chancel arch running parallel. Pointed arches in walls at right angles are slightly cracked, and the north face of the belfry is fractured.

Joint Magistrate's bungalow.

A wall coursing N. 75° W. displays a crack hading W. at 10°.

Kacheri.

Several cracks on an E.—W. course run through the building.

Police barracks. Fractures run E.—W. through arched roofs, and the cross-walls are separated from the main walls.

The east face has moved outwards about ¼ inch at the top.

Major Philson's bungalow. Arches running E.—W. are fractured. Partition walls running N.—S. have moved at right angles. The upper story of this building was badly injured and had been demolished soon after the quake.

Mosque near railway station. A minaret, 1½ ft. × 5½ ft., was cracked at the base, and now leans to the north. The horizontal displacement of the same is ½ inch to E. The east face is cracked vertically.

Public Works Department, Canals, bungalow. Walls coursing S. 30° W. are cracked vertically, whilst those at right angles show evidence of movement in a S.W.—N.E. line. Cracks run through arched roofing in an E.—W. line. The tower is square and contains four stories surmounted by a dome. All faces are cracked, particularly that to S. W. The fractures follow the lines of windows, etc. A faint horizontal crack shows all round the base of the dome.

Cemetery. A plant pot fell over to N. 55° E. Bricks stacked against the north face of a wall coursing N. 75° W. fell outwards to the north, and to a lesser degree to east.

Ground fissures. A large number of earth fissures were found in low alluvial ground through which flows the Solani stream, at a point from half to one mile east of Rurki.

The general direction of the fissures is N. 80° E., but they almost invariably run parallel to the direction of the nearest ditch or stream even though such may be hundreds of feet distant. The average length of a single fissure is about 100 feet. As a rule several are found running parallel to, and a few feet from, one another, so that a series of cracks is continued for hundreds of yards. The largest fissure seen is 10 feet from the low bank of the Solani stream, and runs parallel to the bank on a N.W.—S.E. line. It is 62 feet long

20 inches wide at the top, 15 inches wide at the bottom and 14 inches deep. The width of a large number varies from 1 to 10 inches, with a measurable depth of one to five feet. Sinking of the ground as a rule accompanies the fissures, the vertical displacement varying from 0 to 7 inches, and the depression usually being on the south side of the crack. Villagers declare that sand and water issued forth during the quake, and that this was so is borne out by the fringes of sand which follow many of the fissures. Some of the cracks were found to be filled with water to within 12-inches of the surface.

On a sandy beach in the bed of the stream several small crateriform hollows occur. These are said to have been formed at the time of the quake, but similar depressions, near by, were admitted to have been made either as watering places or by the removal of sand for industrial purposes.

About 2½ miles further east fissures of a similar character to those described above occur. Mr. Hallowes described them as lying between N.—S. and N. 60° W. and from 5 to 50 yards long, the greatest breadth being 1½ feet. Most were filled with sand and water, and some had scattered sand in little mounds along their edges. (See fig. 34.)

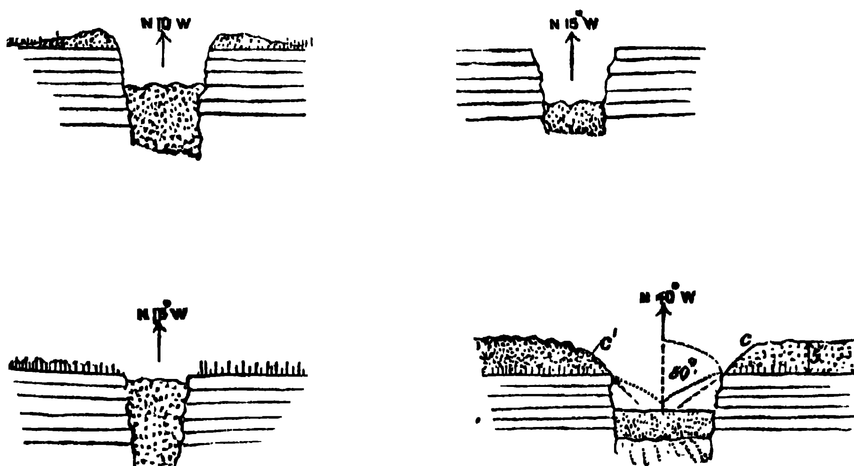


Fig. 34.

Solani aqueduct.

This aqueduct carries the Ganges canal over the Solani stream at a point about ¾ mile west of the locality of the ground fissures just described. Eye-witnesses state that a large quantity of water splashed over the edges during the quake. The duct is aligned S. 33° W.—N. 33° E. and is about 1,000 feet in length. It consists of two parallel channels each 85 feet wide. The current flows S. W. at about three miles per hour. About one hour after the quake Mr. W. H. Rushton, Executive Engineer, Public Works Department, Canals, visited the aqueduct He states that the level of the water was then about five feet below the edges of the channel, and that he could see that the water had splashed over only for about three-quarters of the length of the channel, the north-east end being quite dry. (Fig. 35.)

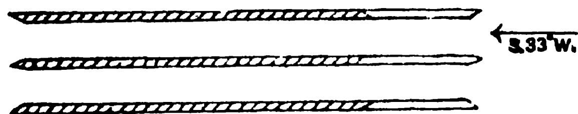


FIG. 35.—The shaded portion was wet at 7-30 on the 4th. Scale 1 inch=400 ft.

The phenomenon is interesting, but unfortunately capable of more than one explanation.

Character and direction of shock, etc.

One observer describes the shock as a continuous vibration for about five seconds. Another states that there were no preliminary tremors, that there were two shocks separated by an interval of 10-20 seconds, the last being much the most severe, and that there were many tremors subsequently. He also noticed a strong wind which sprang up during the first shock and lasted about a minute, the direction of the wind being from west to east.

The general impression of eye-witnesses is that the shock was from west to east. This is borne out by an analysis of the damage to buildings, the principal direction varying from due W. to W. 25° N.

Thomason Engineering College.

Mr. Hallowes found the Engineering College nowhere severely damaged, but the buildings lying N.—S. were much more cracked than those lying E.—W. A clock on a N.—S. wall stopped at 6-13 A.M. A small dome which surmounts the central dome was fissured horizontally at its base and entirely separated from the rest of the structure. (See fig. 36.)

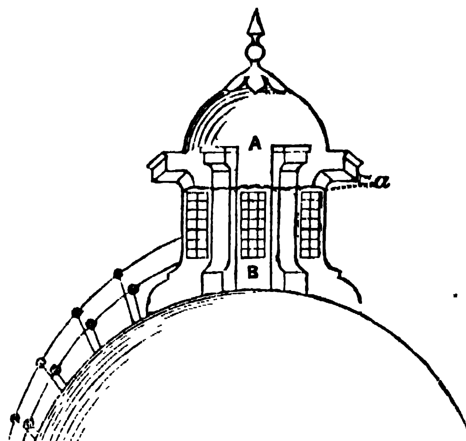


FIG. 36.

Earthquake Forms—Rurki.

Major S. H. Shepperd, R.E., D.S.O., 1st Sappers and Miners.—There were 2 shocks, 2nd much more severe than the 1st. Many tremors afterwards, none before. Interval between 1st and 2nd shocks 10—20 seconds. Direction W.—E. No sound but a very strong wind sprung up and lasted for perhaps 1 minute or more. Direction W.—E. He left his bungalow very quickly. Trees rocked as it were in a high wind. Alarm of birds and beasts. Pony reared straight up at 2nd shock and did not recover his equanimity all day.

Miss M. E. Pope, S. P. G. Mission.—She was indoors sitting in St. Andrew's Church on a bench. There was 1st a distinct vibration of the bench after cracking sound from the roof which was constructed of tiles on girder frame. 2nd, one long shock. The sound between 1 and 2 a continuous increasing sound like heavy goods train coming towards one from W. Direction W.—E. by loose objects and water in basin. Very distinctly felt. Doors rattled and then burst open. Purdahs swung violently. Buildings and trees, including large *shishams*, swayed and seemed to dance, crossing their branches. Some boys noticed movement of the belfry. Heaving of the ground very perceptible. Standing very difficult for a short interval. One person stooping to pick flowers and one squatting over

a fire were thrown down. Alarm bells in telegraph office (next compound) set ringing. Pendulum clock stopped at 6-10.* Wall lamp glasses broken. Canal banks wetted about 3 feet up. Water very muddy 3 hours later. Small chimney ornaments thrown E. Pictures slightly displaced on N.—S. walls. Church lamps oscillated violently. All went out of church. Difficult to stand. On re-entering when the shock was over (to finish the service) the hanging lamps were gyrating so much that there was no direction. Amount of motion 3 feet from vertical in swing of not less than 20 feet.

Major H. J. Sherwood, R.E.—One severe shock N.—S. On plaster falling he went outside. Motion in the verandah so distinct that he felt himself rolling about as if on deck of a ship in a moderate sea. Bead "chick" swung violently N.—S. Arches facing N.—S. cracked. Arches facing E.—W. hardly affected. Two jars on shelf on N. side of room in R. E. mess fell to the floor. Tank water lapped over N.—S.

Mr. P. P. Phillips, Ph.D., Prof. of Chemistry, Thomason Engineering College, and Officiating Superintendent, Meteorogical Observatory.—Time began at 6-15, most violent at 6-17—6-18. Direction N.—S. Five natives were killed. Earth fissures on the banks of the Solani river from which water in large quantities exuded. Sounds resembled thunder. A wave 5 feet high passed down the canal. Much water washed over the banks of the Solani aqueduct and entered the river below. Several pictures thrown from walls facing S. Walls most damaged were internal walls running E.—W. Cracks generally vertical. Water in college store tanks swayed N.—S. Tanks stood on iron frames 18 to 20 feet high. They were emptied by the shock. A suspended lamp swung 3 feet from the vertical N.—S..

Saharanpur.

Sharanpur is similarly placed to Rurki with respect to the Dehra-Mussoorie epicentral tract. Besides being the chief town of the district it is celebrated for its fine Botanical Gardens. Mr. Simpson's account continues :—

Time records.

The most reliable time observation is 6-11 A.M. recorded by Major J. M. Burn, R.E., an officer of the Survey of India, who happened to be on the railway station platform at the time. Neither the railway nor the post office clocks were affected.

Damage in the Civil Station.

The tower of the church is cracked on all faces in the two upper stories, the fractures running between corners and windows.

* Known to be slow.

Mr. C. Powell's bungalow.—This is a kutcha brick and mud building facing N. 55° E. Three arches of the front verandah fell outwards. An arch coursing N. E. was badly fractured. There are a number of cracks in the corners of rooms. A hanging lamp swung N. E.—S. W.

American Mission Church.—A brick and mortar building oriented due E.—W. The four corners of the building have opened out and cracks have developed in E.—W. walls. Two feet of the brickwork forming the top of the conical spire were displaced a distance of 2 inches towards the west. In the mission bungalows a chimney projecting through a roof sloping south fell to the south. Arches running E.—W. suffered slightly.

Judicial Kacheri.—The damage is trifling. Walls coursing N.—S. show slight cracks heading S. at 10°. Walls at right angles display evidence of N.—S. motion.

Collector's Kacheri.—Walls running N.—S. show slight damage. Verandahs at front and back are separated from building by slight cracks running N.—S. Three ceiling beams running N.—S. are broken at the middle, apparently by end thrust. In the criminal records room are a number of lofty book cases oriented due E.—W. One of them now leans 1° to W., and another 3° to E. A number of books fell off to N..

Mosque near the Kacheri.—Minarets on the east face are cracked at the base and lean to the east slightly.

Police Station.—A barrack aligned N. 20° W.—S. 20° E. shows diagonal fracturing on the north and south faces. The walls at right angles are held by a tied-arch roof, and are uninjured.

Botanical Gardens.

The largest building is the museum. It is an oblong structure, aligned N. 35° W., consisting of a central nave with two enclosed verandahs. (See fig. 37.) The roof is carried on two interior arches, both of which were so badly fractured that they have been taken down. Walls parallel to the main axis are fractured horizontally, and those at right angles vertically. The verandah pillars on the east and west fronts are cracked through at the

base. The damage provides strong evidence of motion across the building.

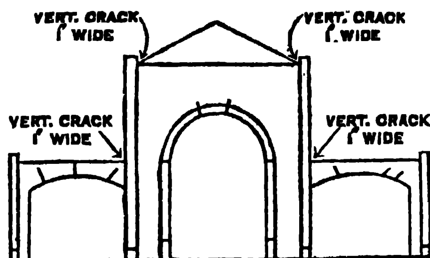


Fig. 37.

In the Superintendent's bungalow a plant pot on a stand fell to N. 4° E.

* In the seed godown, a number of ghurrahs piled one above the other fell to N. 60° W. The direction of fall was influenced by the fact of the pots being stacked in rows.

N. W. Railway workshops.

Water from an overhead tank was thrown out to N. 20° E.—S. 20° W. A boiler-house near by shows strong evidence of motion in the same direction.

The bazar.

Haji Nasrala's theatre.—A heavy cornice facing N. 75° E. fell outwards in that direction. Walls coursing E.—W. are fractured in a few cases.

Hasmat's house.—Walls running N. 60° E. display strong fractures; those at right angles being uninjured.

Kandan Lal's house.—A wall coursing S. 75° E. is strongly fractured. A large number of houses facing S. 75° E. show large cracks in wall running S. 75° E. Many walls at right angles to this direction lean to S. 75° E.

Jumma musjid.—This temple faces S. 73° E. and is a copy of the mosque of the same name at Delhi. A portion of the outer wall fell outwards to S. 73° E. The two chief minarets are octagons of face 4 feet 9 inches, and about 90 feet high. They carry 8-pillared cupolas. In the northern minaret a pillar on the east was broken and fell inside. The pillars on the S. W. side are severely fractured. In the southern

minaret the pillar on the S. E. side fell outwards and those on the N. W. are cracked. The line of damage to this minaret is approximately N. W.—S. E. Two smaller minarets over the great entrance-gate fell towards the west, about 2 feet being broken off in each case.

A tall plaster ornament on a wall near the mosque is carried on a vertical iron rod. This leans over to S. 20° W. at an angle of 10°.

Radha Lal's house.—A wall coursing N. 20° E. fell outwards to S. 70° E. Walls at right angles display vertical fracturing.

Ground fissures.

There are rumours of ground fissuring in the neighbourhood, but no information of their locality could be obtained.

Character of shock, etc.

One observer describes the shock as a series of rapid tremors lasting from 15 to 30 seconds. Another estimates the duration at 50 seconds. Noises like the passing of a heavy goods train were heard.

From an analysis of the damage to buildings, etc., the direction of motion appears to have been between E.—W. and N. E.—S. W.

Earthquake Forms—Saharanpur.

Mr. H. M. Leake, Botanic Gardens.—The main shock is described as a rapid series of tremors lasting for 15 to 30 seconds but without any marked difference in intensity. Every building in the gardens has suffered damage, which is limited to cracks in walls and corners. Palm in pot 3 ft. high overturned. Piles of "ghurras" overturned.

Major J. M. Burn, R.E., Survey of India.—Time 6-11 A.M. by chronometer watch checked with railway time (he was standing on the station platform at the time of the shock). One shock lasting about 50 seconds. Direction N. W.—S. E. There was much noise exactly like a heavy goods train going at full speed through the station. Lamps were swinging about at right angles to the railway station.

CHAPTER III.

LARGE CITIES OF THE PLAINS IN THE VICINITY OF THE VIIth ISOSEIST.

The area described in this chapter was examined by Mr. E. H. Pascoe. Its title to recognition as a special unit depends on the consideration that it includes most of the larger cities lying away from the hills on the alluvial plains, and within a radial distance from the epicentral regions of about 125 miles. Being connected up by the chief railway systems of Northern India, the various centres were easily accessible without loss of time. In describing the damage to buildings in this zone, it is necessary to guard against a misconception. It will be remembered that in Part I, Chapter I, I have already shown that places such as Pathankot and Dera Gopipur, being only at 40 and 20 miles respectively from the main epicentre, showed no appreciable damage (see pp. 8, 39). Contrasting this with Lahore, Ludhiana, Sialkote, etc., at distances of over 100 miles away, it might at first appear that there was more damage done at the distant places than at the nearer. Against this impression should be set the smallness of the towns of Pathankot and Dera Gopipur, and the absence in them of complicated architectural structures. Within the larger cities of the plains it would be quite possible to isolate many groups of buildings of the size of Pathankot and Dera Gopipur and showing as little damage. The aggregate effects of an earthquake in a large city must always be great; but this should not be confused with the average effect per building unit which is the only fair way to estimate destructive intensity.

Area defined.

Mr. Pascoe's tour embraced the following cities and towns:—Lahore (with Shahdara and Mian Mir), Jullundur, Amritsar, Tarn Taran, Ferozepur, Wazirabad, Gujranwala, Gujrat, Sialkot, Jamu, Ludhiana, Multan and Phagwara. After his description of each there follow extracts from the earthquake forms in the usual way.

Lahore (including Mian Mir and Shahdara).

Mr. Pascoe's description somewhat abridged is as follows:—

In spite of the size and importance of such a city as Lahore, the evidence as to the exact minute the main shock was felt is somewhat conflicting.

Time observations.

At the telegraph office no clocks stopped, and no satisfactory observations of the time seem to have been recorded.

At the railway station, the clock in the telegraph office stopped at 6-10 A.M. This clock is corrected every day at 4 P.M. by wire from Madras, and had been so corrected on Monday, April 3rd. According to the stationmaster and the train inspector the drum-clock on platform 5 was the only one in the station which did not stop. Two other platform drum-clocks, whose pendulums swing in the same direction stopped at 6-10 A.M. exactly. All platform clocks are put right every Monday by the clock in the telegraph office, and had been so corrected on Monday, April 3rd.

Other time estimates of 6-12, 6-13 and 6-15½ from less reliable sources have been given.

The general testimony is that there were two slight preliminary shocks separated by an interval of two or three seconds during which there was perceptible vibration. By many these two preliminary tremors have been, apparently, indistinguishable, and are described as one shock lasting for three or four seconds. The interval between the last preliminary tremor and the main shock was estimated to be 5 or 6 seconds. One observer mentions a slight shock of short duration about 10 minutes after the severe shock. Continuous tremors occurred for about half an hour after the main shock, and there were distinct vibrations at various intervals up to 8 A.M. causing doors to rattle.

Number of shocks.

No unusual sound, save that caused by buildings falling and doors rattling, is reported.

Sound.

Effect on buildings.

The Town Hall.

The Town Hall has suffered more severely than any other building in Lahore, and will require a great deal of reconstruction. It is a large substantial rectangular two-storied building of red brick, 114 ft. by 72 ft. and 48 feet in height, with its longer axis running N. 15° E. (see pl. 18). At the north corners were two large but not lofty square towers, bearing a very heavy roof structure, including a large central dome and four corner turrets, each turret being crowned with a solid brick globe. It is to the presence of these two towers that the mischief is due, for, while they themselves are badly wrecked and have wrecked adjacent staircases and verandahs, the southern portion beyond the lateral turrets is quite intact with scarcely a crack over its arches. The intermediate portion has sustained injury only where it projects above the main structure; a turret and two globes having been lost on one side, and two globes on the other. (See pl. 18 and plan pl. 23.)

An eye-witness describes the fall of the towers as seen from a bungalow from which the front or northern end of the Town Hall is visible. They appeared first to lurch forward towards the north, recover, and again lurch forward, the upper portion falling.

At first sight it appears difficult to explain why this building should have suffered so conspicuously, since there are several large buildings close at hand, which are either untouched or show slight cracks only. (*Cf.* New Law Courts, pl. 19, lower fig.)

It appears reasonable to attribute the destruction to the weighty roofs of the towers and the quite inadequate support beneath. From calculations based on the dimensions, and specific gravity of the brick, the weight of the central dome, which was practically of solid brick-work, was approximately 38 tons, that of each turret about 2 tons, and that of each globe about 12 cwt. So that, besides the weight of the actual roof itself and its wide cornice, the brick pillars below had to support at least 48 tons.

The effect of the earthquake upon the Town Hall can perhaps be explained by assuming that it was struck by two impulses from different directions, one from the N. or N. E. and a less severe one from the E. S. E. or S. E.

The Post Office was built on the site of a filled-up marsh, and is a large, well-built, two-storied building of red brick consisting of two rectangular "arms" about 260 feet long, 67⅓ feet wide, and about 40 feet high, one arm running due N. W., the other W. 15° S. with an angle of 60° between their directions, thus forming two sides of an equilateral triangle. The angle is truncated by a short connecting portion through the centre of which rises a massive clock tower, F, extending some 53 feet above the flat roof. At the corners A, B C, D, are four smaller towers, rising 28 feet above the roof, and a slightly larger tower, E, close to the clock tower, occurs at the angle of the building. (See pl. 24.)

The Post Office.

There has been very little damage done to the walls and rooms, the chief features of interest being visible on the roof. The portions of the four corner towers A, B, C, D, projecting above the roof, have been badly cracked and shaken: whilst the two towers E and F are both quite sound owing doubtless to less oscillation there than at the free end of the wings.

All round the margin of the roof runs a low brick parapet in which are embedded a pair of brick gable-ends, (G, H, and K, L,) halfway between the free and fixed ends of each arm of the building. The two gable-ends in the N. W. arm (G, H,) are practically unharmed while the pair in the other arm (K, L,) are seriously affected. A bad crack runs along the base of each and is flanked by a pair of irregular vertical cracks passing from the basal corners of the gable-end through the parapet wall: the one on the south (L) is in a more or less dangerous condition, and was seen to oscillate and lean over by a man standing on the ground below. (See fig. 38.)

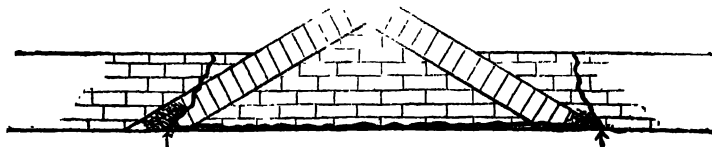


Fig. 38.

From this it is evident that the shock struck the building in a direction more nearly at right angles to the western arm than to the north-western arm.

In the post-master's private quarters on the first floor at the end of the western arm, a considerable quantity of plaster fell from transverse walls but none from longitudinal walls. A crack also ran down from tower C, followed the direction of the longitudinal wall through two rooms and then passed transversely across the building, making it appear as if there had been a tendency to shake off the end portion of the building.

In the north-western arm, plaster fell from one wall only, a longitudinal one, in a room near the tower A.

On the ground floor there are a few slight vertical cracks, and the ceilings appear to have been lifted up in a few cases.

The Central Museum.

In Lahore Central Museum the roof of the long and lofty central room contains twelve separate barrel-arched ceilings of brick and plaster, each being perforated by a circular aperture in the centre for lighting purposes. The 1st, 2nd, and 12th ceilings are cracked, the 1st and 2nd diagonally, and the 12th more irregularly, but with a diagonal tendency. (See fig. 39.) This room lies due N. and S. In another room with the same bearings, one of a similar set of ceilings is cracked diagonally in the same way.

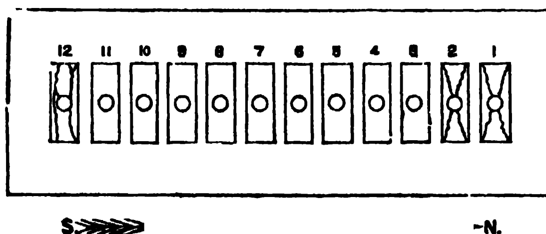


FIG. 39.

On the corners of the roof solid dome-like turrets of brickwork pierced by small arched doorways on the four sides, were severely shaken and cracked.

School of Art and Public Library.

The School of Art is a square building connected with the Museum, but built at a different time: the walls face N., S., E. and W. Each corner bears a turret, and although all these are exactly similar and presumably equally well built, the two on the N. are practically intact

while the southern pair were so badly cracked, as to necessitate their removal. Curiously enough this is also the case with the Public Library which lies close to the School of Art. The two cupolas on the S. are seriously injured, while those on the N. are said to be unaffected.

New Law Courts.

The New Law Courts (see pl. 19) which are less than three quarters of a mile from the Town Hall comprise a large, well constructed, irregular pile of buildings, with considerable variation in the heights of several portions. However, no independent oscillation has taken place, the two corner brick towers have not separated in the least from the adjacent verandah, there is no trace of a crack between the porch and main building, and the whole assemblage of buildings has escaped with a few insignificant vertical cracks in one of the rooms. The walls of the court room are decorated with ornamental plaster, but only in three or four places have pieces fallen, and these are very small. This immunity may be due to the fact that the court is a new building. According to enquiries made, it takes at least 12 months for a properly mixed lime containing cement to become rigid; consequently the walls of a new building are elastic, and yield more readily to distortional forces than do those of an older building. I heard of no building in course of construction being damaged. The escape of the two "chattris" overlooking the porch is less easily understood, considering the massiveness of each dome and the slenderness of the supporting pillars. The latter, however are of stone, and to this fact and to the elasticity of the underlying brickwork must be attributed the successful resistance to the jerk. The arches of the several verandahs contain delicate ornamental stone-work, and this is also quite uninjured.

English Church.

On the western end of the gable-roof of the English Protestant church was a rectangular-sectioned brick pedestal bearing a cross. The latter has fallen eastwards and split into two parts upon the gable, the parts having slid down on either side and broken upon the ground. The pedestal is

loosened and shaken, and appears to have swayed E. and W. about its longer axis, no doubt directing the fall of the cross.

Accountant-General's Office.

The Accountant-General's office is not a new building and has several cracks. In the first room the walls run almost due N.* and S., and E. and W. In those running N. and S. are several vertical cracks, some over 1 inch wide, and extending through the whole height of the walls; the walls running E. and W. are free from cracks In the second room the same thing is found: one crack follows the curve of an arched doorway. In the third room there is a vertical crack passing through the key of an arched doorway. Outside, a shattered brick chimney stack has partly fallen.

Deputy Commissioner's Office.

The Deputy Commissioner's office, in the upper of the two stories, has several vertical cracks, especially in corners and over the arches. On the roof there is a more or less continuous crack parallel to the edges and about 1 foot distant from them all round, the four walls having apparently tended to separate at the angles and fall outwards. The chimneys also are cracked. The walls of this building run N. to S. and E. to W.

Market.

The market is an old brick building, like a church in plan, with a central "nave" and two lower side "aisles." Its long axis runs W. 20° N. to E. 20° S. Each side-wall of the "nave" bears seven gable windows surmounted by seven gable-ends which are parallel to the main axis (pl. 19, fig. 1) and the gable roof carries two towers of wood and slate. The western end-wall of the "nave" has separated from the side walls, and fallen bodily outwards. The eastern end-wall has separated from the side walls, a crack from 1 to 2 inches wide extending up each of the latter. The towers are untouched, and none of the gable windows have fallen or received any damage: some of the latter are a little out of plumb, but may have been so before the quake.

A low brick parapet skirts the roof of the "aisles," and has fallen at the western ends of both the latter, breaking the tiles of a verandah beneath, but it is intact along the sides.

* N. 15° W. according to plan furnished by Mr. Worman, Executive Engineer

Clearly the shock has struck this building in a more or less E. to W. or W. to E. direction.

Montgomery Hall.

The Montgomery Hall is a large heavy building of which the main hall has suffered. This is a lofty room around which extends a gallery or internal verandah about 15 feet from the ground. On the south side of the building is a tall porch which has separated a little from the hall. Part of the roof over the gallery adjoining the porch has fallen upon and broken through the gallery floor beneath: this catastrophe was no doubt connected with the movement of the porch, which to some extent appears to have carried with it the wall of the building, in the oscillations, and to have thus drawn the beams of the gallery roof out of their sockets.

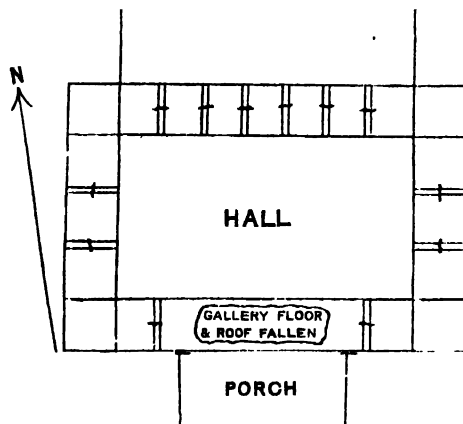


FIG. 40.

The capitals of the porch pillars are cracked, as are also all the keys of the arches over the gallery, as indicated in the diagram (fig. 40).

Education Department.

The Education Department is a long one-storied building, its long axis lying N. 15° E. to S. 15° W. There are many cracks, mostly vertical, and the transverse walls are those chiefly affected.

Railway Station.

In the Railway Station the injury has been extensive, but uniform in nature. The direction of the line and platforms is W. 30° N. to E. 30° S. On one platform the wide-angled gable-roof of the 1st class gentlemen's waiting room has fallen, and there are cracks in the corners: in the 1st class and 2nd class ladies' waiting rooms on the same platform the roofs are dangerously cracked and will have to be taken down. On

platform No. 2, seven rooms in a line have been seriously damaged: the roofs of the Intermediate waiting room and four adjoining offices have fallen, and the roofs of the next two offices are so dangerous as to necessitate their demolition. Cracks in the Intermediate waiting room were confined to the corners where separation of the walls has taken place.

In all the above cases the beams supporting the roofs ran transversely to the direction of the platforms, *i.e.*, in a direction N. 30° E. to S. 30° W. Owing to the oscillation of the buildings about their long axis, the whole length of the longitudinal wall appears to have separated as a whole from the transverse walls and to have forced the beams out of their sockets. The actual walls are in two or three rooms entirely without cracks.

Above the roof of one platform was a longitudinal parapet wall supporting in one place a brick stack, into the top of which was fixed a large iron flag. This flag fell from the stack, tearing away with it about a foot of the brickwork, and was projected in a direction at right angles to the parapet wall, *viz.*, towards N. 30° E., and fell about 10 feet away from its own vertical, on to the platform roof through which it tore a large hole and finally dropped on to the platform.

Weight of flag = 8 seers.
Height of flag = 4 feet.
Height of top of the stack above the platform = 46 feet.
Height of platform roof above the platform = abt. 10 feet.

From these data, the horizontal component of the velocity of the flag is about 6·5 feet per second.

Bible Society's premises.

In two opposite walls (direction W. 20° N. to E. 20° S.) in the first room of the Bible Society's premises are two bricked up arches which have moved, causing the plaster to fall along the juncture. The second room contains two bricked-up arches in exactly similar positions and similarly affected.

In the store-room many books and large tins were projected off shelves running along walls in the direction N. 20° E. to S. 20° W.; nothing with the exception of a few insecurely placed books, fell from the shelves at right angles to these.

On the roof is a kind of open shed consisting of six substantial rectangular brick pillars supporting a heavy wooden roof. The structure shows signs of having rocked to and fro from W. 20° N. to E. 20° S. The pillars are cracked at the tops and have either separated from the roof supporting them or cracked horizontally close to the base.

Office of the Inspector-General of Police.

In the offices of the Inspector-General of Police there are many vertical cracks but no serious damage, and no indication of the direction of shock.

The Police Court was unharmed save for a few vertical cracks.

Lahore City: Rajah Khirti Singh's palace.

In Lahore City, situated to the north of the town, the Rajah Khirti Singh's Palace has suffered severely. It consists of an irregular group of red-brick buildings, many of them lofty and most of them old and poorly built: some were in need of repair before the earthquake. A great number of rooms exhibit cracks large and small, nearly all vertical, and, owing to the irregularity of the structure, of little scientific interest. The most grievous damage was done where the floor of an upper story gave way. The wooden beams had rotted just outside their sockets and snapped at both ends when disturbed by the vibration.

Wazir Khan's mosque.

The features of interest in the mosque of Wazir Khan are the four lofty minars at the corners of the spacious court. These are some 90 feet in height, built of brick, octagonal in section, slightly tapering and connected with each other on the north and south sides of the court by low walls on the east connected by the entrance gateway to which the minars are also joined by low walls, and on the west by the entrance to the sanctuary. All four minars are now leaning outwards away from the centre of the court, but bending rather more towards the north and south than towards the east and west.

On the summit of each minar are eight pillars supporting a cupola: several of these pillars are cracked, and there is danger of the cupolas falling. The eight spaces between the pillars are alternately open and bricked-up, in pursuance of some religious idea, and in the N. W. minar, the four masses of brickwork between the pillars have all fallen.

Golden Mosque.

The Golden Mosque is a much smaller mosque. At the N. W. and S. W. corners of the court, and joined throughout half their height to the sanctuary, are two minarets originally crowned with cupolas of gilt brass. These cupolas have fallen, first on to the walls enclosing the sacred area fracturing the brickwork, and ultimately into the streets. The minarets, though somewhat slender, were undamaged.

The height of the minarets was 10½ feet and the diameter of the more or less spherical cupolas was about 4 feet. The cupola on the S. was projected 8½ feet away from the centre of the minaret base, and in a direction S. 30° W. The cupola on the N. was projected 11 feet away from the centre of its minaret base, falling W. 30° N. It will be noticed that these directions are at right angles. (Fig. 41.)

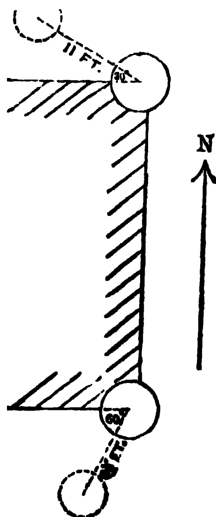


FIG. 41.

The horizontal velocity of the N. cupola was thus 6·91 feet per second, that of the S. cupola, 5·55 feet per second. The resultant of these is 8·74 feet per second from E. 7½° N. to W. 7½° S.

Either there were two shocks from different directions, or else the sanctuary building must have influenced the direction in which the minarets vibrated.

Most houses in the city are cracked, and many to such an extent as to require considerable repair. Not very much has fallen, however, and this may be put down to the fact that the houses are crowded together, mutually supporting one another. In two or three cases roofs have fallen.

The Shish Mahal has been cracked, and also some of the bungalows.

Fort.

One of the latter a long one-storied building lying E. and W. has lost a large portion of a brick parapet on the walls whose direction is E. to W.; the parapet on the N. to S. walls is intact.

Shahi Mosque.

The Shahi Mosque opposite the Fort is a good illustration of the fact that in the Plains, *i.e.*, at some distance from the centre of disturbance, stone edifices have suffered less than brick. No indications of disturbance could be discovered on the mosque, in spite of the slenderness of the small pinnacles and pillars.

Shahdara: Jehangir's Tomb.

Jehangir's Tomb is on the other side of the Ravi, and lies to the N. W. of Lahore City. It is a low square building built largely of marble and covering a large area; around it extends a verandah many of the arches of which are cracked, but it was almost impossible to distinguish between the numerous old cracks and those caused by the earthquake.

At the corners of the building are four tall handsome minars, 93 feet in height and built of stone and marble, and connected with the tomb below, from which there appears to be no sign of separation. Nevertheless three at least of the minars are leaning away from centre, that on the N. W. distinctly, that on the S. W. slightly, and that on the

S. E. very slightly : the N. E. one is practically vertical. Each minar is octagonal in section and bears at its summit a massive marble cupola upon eight octagonal marble pillars.

On examining the N. W. cupola, the pillars were found to be chipped around their bases and to a less extent around their tops giving the impression that there had been either successive movements in more than one direction or a gyratory movement. It was interesting, though confusing, to find older impressions of chipping in the same position, showing that movement had occurred here before. A carved perforated marble fencing extends from pillar to pillar, and this also has been chipped at its ends by the movement of the pillars. In the S. W. minar a piece of this fencing was thrown down.

Factory chimneys.

There are several tall brick Factory chimneys close to the Railway line near Lahore, but I heard of none having fallen.

Mian Mir.

Several of the military bungalows at Mian Mir have been cracked, the most conspicuous being that of E. Company. This, like the others, is a very long one-storied building lying due N. and S. with about a dozen transverse partition walls, each containing a large arched doorway : all these arches are cracked up the centre. The longitudinal walls with their arches are unaffected, except that they have separated from the partition wall. This is also the case with the arches of the verandah running N. and S. : there are twenty-four of these on each side and none have been cracked.

Nature, Intensity and Direction of shock.

Two observers remarked independently on the jerky nature of the shock : one of them had experienced nine earthquakes and the other three, and both stated that the jerk was the most abrupt they had ever felt.

With regard to the intensity, the disturbance was universally felt causing considerable alarm, most of the inhabitants either left their houses or took refuge under arches and doorways. There was no difficulty in standing provided the feet were kept apart. Trees rustled as in a strong wind, books were projected from shelves, articles fell from mantelpieces, and a bookcase standing against a wall was overthrown.

The intensity, however, can best be judged by the effect upon buildings. (See above.) There are very few houses which do not show some trace of the earthquake in the form of cracks, especially above arches of doorways and windows. Another very common thing here and elsewhere is the formation of cracks in the corners of rooms, due to the separation of the walls which, instead of being properly bonded together at the corners, have simply been built one up against another.

Twenty-five lives were lost in Lahore through the earthquake.

A swinging lamp hanging from the ceiling by a wire 14 feet long described an arc of 3½—4 feet, [1] another lamp hanging by a wire of about the same length is said to have swung through an arc of 1½ feet.[2] The difference of swing is probably due to the difference of direction of oscillation, the latter being largely governed by the orientation of the house. The first lamp swung due N. and S. parallel to two walls of a room : the second swung N. 20° E. to S. 20° W., also parallel to the sides of a room.

Water in a hand-basin was seen to splash over the sides towards the N. E. and S. W.

In a house whose walls run N. N. E. to S. S. W. and perpendicular to this a bookcase leaning against a W. N. W. to E. S. E. wall fell into the room. Water from an elliptical bath lying W. N. W. and E. S. E. was seen to splash out towards the N. N. E. and S. S. W. An iron ladder leaning against the wall was seen to vibrate violently up and down.[3]

The pole of a tent was seen to sway approximately E. to W.[4]

In the central museum some vases standing on a dusty glass surface are said to have moved towards the S. E., tracing paths from ⅛ to 1½ inches long in the dust[5]; a model railway carriage on lines pointing E. and W. dashed into and shattered the glass on the W. end of the case.

1 Mr. Percy Brown, Curator of Museum.
2 Mr. Deverell, Nedou's Hotel.
3 Personal Assistant to the Inspector-General of Police.
4 Col. McConaghey.
5 P. Brown, Curator.

In an officer's quarters at Mian Mir[1] 'photos and other articles fell into the fender off a mantelpiece lying W. 30.° N. to E. 30° S.: the mantelpiece truncated the corner of a room.

Summarising the evidence as to direction of the shock, we have :—

Town Hall.—Approximately from N. and possibly also from E. S. E.

Post Office.—Approximately from N. or N. N. W. (Any shock from E. S. E. would probably have little effect. See plan.)

Museum.—Approximately from N. E. and also approximately from S. E. (movement of vases, etc.).

Accountant-General's Office.—More from N. than from E.

Market.—Approximately from E. S. E.

Railway station.—Approximately from E. N. E.

Education Office.—Approximately from E. S. E.

Bible Society.—Approximately from E. S. E.

Golden temple.—Either one shock from N. or else two shocks, one from E. 30° S., the other from N. 30° E.

Mian Mir.—More from E. than from N.

It thus appears that either the waves were of a somewhat complex type affecting some buildings differently from others, or else there were at least two shocks proceeding from different points of the compass.

Earthquake Forms—Lahore.

Mr. U. S. Worman, Executive Engineer, 2nd Lahore Division.—Sent plans of three public buildings in Lahore showing generally vertical cracks.

Mr. A. T. Gibson, Imperial Forest School (Dehra Dun).—Time 6 7 A.M. by watch compared with North Western Railway station time. There were first no preliminary tremors, second a sharp oscillation for 1 minute of equal intensity throughout. Third the movement died away. Direction S. W. to N. E. Very distinctly felt. Pictures on N.—S. walls moved. Photos. facing N. fell to S. Walls split in corners. The first shock was accompanied by a strong wind. No other sounds heard.

[1] Captain Spry.

Mr. A. Greene, Sub-Assistant Superintendent, Telegraph Office.—Time 6-10 A.M. Chest-of-drawers upset accompanied by a breeze and fall in temperature. A very severe shock. He partly lost his balance during the second shock.

Mr. F. C. Dixon, C.E. (of Adams & Co., Agra).—There was a continuous shaking growing in intensity but no separate shocks. He first thought it was a dog under the bed. Doors and windows rattled, bed shook more violently. He then went outside. No sound.

Babu Jaspat Rai, Chief Observer, Magnetic Observatory.—Time 6-12 by a Government watch keeping accurate time and often compared with Observatory clocks. Direction S. or S. S. W. Furniture trembled, houses shook, cracks in most houses, lamps, punkhas and other hanging things swung from S.—N. Many people buried under wreck of houses. Bottles and glasses overturned on shelves. Pendulum clocks in the Observatory were stopped. Charts of self-recording instruments all show the exact time of the occurrence, namely, 5-48 A.M. local time which = 6-12 A.M. Madras time.

Mr. U. T. Janson, Assistant Engineer, North Western Railway.—Time 6-13 by clocks stopped. There were two shocks, the first being the more intense, and woke him up in Nedou's Hotel. At first the direction was N. 20° E. which increased in intensity for about 30 seconds. Then the direction changed suddenly to one at right angles, the intensity remaining the same. Outside he had to keep his feet wide apart to keep his balance. The waves now appeared to come from all directions, almost in a gyratory manner. Trees lashed as in a strong wind. Finally the shocks subsided to a tremor.

Mr. P. Brown, Curator, Central Museum.—Time 6-15½, believed correct with railway time. Three strong sets of vibrations, the 3rd the strongest. As he got out of bed he was thrown down by the 2nd shock. Hanging lamp, 14 ft. long wire, had a N.—S. swing of 3½ to 4 ft. arc. Water from basin splashed N.E.—S.W. No sound heard. Several articles in the museum were overturned and many moved. From examination of hundreds of small articles he noted the general direction of travel to be S. E., especially in the case of glass and earthenware articles on plate glass shelves whose path was traced in the dust. Amount of movement ⅛ inch to 1½ inch.

Earthquake Forms—Mian Mir.

Major T. Y. Seddon, 34th Pioneers.—Time 6-7 (clock stopped). There was first a severe rumbling, culminating secondly in one sudden shock. Thirdly, tremulous vibration for 30 seconds after the big shock. It was most distinctly felt.

Imani Din, Sub-Postmaster.—Time 6-10 by watch in accordance with telegraph time. First 3 or 4 tremulous vibrations, 2nd 2 principal shocks, 3 or 4 seconds each. Direction E.—W. by parcel scale. Everything seemed vibrating. A rattling sound was "felt" before the main shock.

Jullundur.

Mr. Pascoe's description continues:—

The time is wired daily from Lahore to the telegraph office of the Cantonment Railway Station. The Station-master recorded 6-10 by the clock in his room, and this was correct according to the telegraph office clock.

Time observations.

The Sub-Divisional Officer of Military Works, Sergeant Stuart, recorded 6-12 by his watch, timed by the daily gun which is said to be generally correct within a minute. I found it over two minutes late, however, on the one occasion I had of testing it.

The officer in charge of the telegraph office reports that the main shock occurred at 6-10 A.M., the office clock stopping exactly at this hour. At the Post and Telegraph Office, Jullundur City, no clocks stopped, and no time was observed.

According to the report of the telegraph office, the main shock, which lasted for about $1\frac{3}{4}$ minutes, was followed by slight shocks as follows:—

Duration and number of shocks.

One at 6-30, duration 2 or 3 seconds; others at 9-30 A.M., 1-55 P.M. and 10 P.M.; but these are evidently aftershocks, and not parts of the original seismic movement.

Sound.

No unusual sound appears to have been noticed.

In the Railway Station a few bricks fell, and a waiting room has two oblique cracks in two opposite walls lying N. W. to S. E., the cracks heading towards the S. E. The station-master's private quarters are old, and low, with several bad cracks, some of which are irregularly oblique.

Effects upon buildings: Cantonment Railway Station.

In the Police station there was a tendency for the S. wall to be thrown off, since there are two large upright cracks opposite one another in the southern ends of the E. and W. walls.

Police Station.

Isolation Hospital.

In the Isolation Hospital, a small square one-storied house, arches in the verandah were cracked.

Church.

A stone cross on the church fell towards the S. W. and was fractured upon the roof.

A considerable area was covered by a regularly arranged series of bungalows, most of which were very similar in general plan and architecture, in height, and in the quality of their building material. All the bungalows were inspected with a view to discovering any lines of interference, but nothing of this nature could be identified. The following brief summary will aid in giving an idea of the seismic intensity.

Bungalows.

The bungalows are all one-storied, have a solid appearance due to the thick burnt brick walls, but the latter have uneven surfaces, and are built with a poor cement. A typical bungalow consists of a lofty central portion and two lower wings of the same height as the verandah: the latter, as well as the end of the house contiguous to it, is semi-circular.

No. 3. A portion of the western wall above the side wing has fallen inwards towards the E.; there are cracks all over the house, and plaster is missing in several places. This building did not appear strong

No. 9. The arches of the verandah which is on the S. are badly cracked; bricks fell from one arch.

No. 11. There are two curved verandahs, one on the N. and one on the S. The curved south main wall above the verandah had to be rebuilt, while the N. main wall, also curved, had begun to separate from the rest of the building.

No. 12. The S. W. upper corner of a chimney stack on the S. margin of the house has broken off and fallen towards the S. W. The verandah is situated on the N. side of the house, the upper wall of which is here badly cracked. A chimney just above fell on to the verandah roof; and a second one, also on the N., was badly shaken, and partly fell.

No. 15. The upper walls above the wings and verandah are cracked all round. In this case the longer axis points E. and W., the verandah and entrance occurring on the E.

No. 36. Here the verandah is on the N. side of the house. The upper part of the N. wall has fallen on to the verandah and the latter has collapsed in consequence.

No. 40. The verandah is on the S. Part of the S. wall above the verandah fell through the roof of the latter.

No. 43. The verandah is on the N. The curved N. wall of the upper storey separated from the remainder.

No. 50. Here the verandah is on the S., but contrary to the usual state of affairs, the cracks predominate on the N. side which tended to separate from the rest of the house. The N. wall had to be largely rebuilt.

No. 62. The verandah is on the N. Two portions of the upper part of the wall, one on the N. E., the other on the E., fell outwards.

No. 78. The verandah is on the W. The curved S. W. portion of the house wall fell towards the S. W. overthrowing half of the verandah beneath. The rest of the building is intact. The parts which have suffered most are :—

The verandah and the higher parts of the house walls projecting above the wings and verandah, especially when these walls are curved.

The general direction of shock indicated by the bungalows is N. E., N. N. E. or N.

Cantonment bazar.

The Cantonment bazar consists almost entirely of a series of low one-storied booths, poorly built, and in many cases sharing a common roof. This roof was generally skirted by a low parapet parallel to the streets, and composed either of open brickwork or brickwork and vertical hollow earthen pipes. Several portions of this parapet have either fallen or are cracked at the base and leaning : this has happened more especially at corners. Of parapets running N. and S. about twice as much fell as of those running W. and E. Moreover in one corner, the portion running N. and S. has fallen towards the E. while the E. to W. portion is still *in situ* but leaning considerably towards the N. the base being cracked through. This lends colour to the view that the waves came more from the E. than from the N., but the parapets were old and in bad repair, and the evidence from their fall is of limited value.

Other cases of injury are as follows :—

In a native hut whose walls on the N., S. and E. sides are of burnt

brick, the W. wall, which was of unburnt brick, has fallen outwards. There is a wide crack in the E. wall near the N. corner.

In a second burnt brick hut, the wall on the S. has fallen outwards and the E. wall was pulled down on account of its dangerous cracks.

In two cases arches running N. and S. over native booths have collapsed; in one case the arch was near a corner of which the wall running E. to W. is leaning considerably towards the N.

In another house, the S. wall had to be pulled down by reason of wide cracks in the walls on the E. and W. near the S. corner.

Military lines.

The Military lines have suffered less than might have been expected after witnessing the condition of the Cantonment bungalows. A number of chimneys have been so shaken as to require rebuilding, but none have actually fallen.

Bungalow No. 18, the married quarters of the 1st Northamptshire Regiment, has received the greatest injury. This is a long one-storied building which is more or less sound in the central portion, but there are serious cracks at each extremity.

In a double-storied barracks pointing N. E. by E. and S. W. by W. many of the arches irrespective of their direction are cracked.

Jullundur City.

Jullundur City, about 5 miles N. W. of the Cantonment, comprises two or three Government offices, the church, the Deputy Commissioner's house, and the bazar.

Post Office.

The post office is a small building with its longer axis E. N. E.— W. S. W. The cracks, which are vertical, predominate in the walls parallel to this axis, but are not serious.

The Magistrate's Court has a few slight cracks.

In the dining room of the Deputy Commissioner's bungalow a quantity of plaster fell from the upper region of the walls on the N. and S., while one small piece only fell from the wall on the E. and none from the W. wall. As in the post office at Lahore, so here, there appears to be a tendency for plaster to fall from walls more nearly parallel to the line of shock than from those more oblique.

The church is uninjured.

Bazar.

The houses in the bazar are rudely built, and the walls in many cases have obviously been out of the perpendicular for some time. There are several two-storied houses, and nearly all these have been seriously cracked.

A small minaret of a mosque has fallen towards the S.

In five cases roofs have fallen, and in one case the whole upper story is missing.

Intensity.

The shock was felt universally and many of the inhabitants removed to tents owing either to the dangerous condition of their bungalows, or to the inconvenience associated with repairs. Practically all houses are cracked, and in many cases portions of the walls have fallen. It is difficult to compare the effect on this town with that upon Lahore, but it seems reasonable to ascribe the greater damage inflicted upon the latter city to the presence of large buildings, especially to buildings of two stories, rather than to any difference in the intensity of shock. If anything, the shock was slightly greater at Jullundur, due allowance being made for imperfect construction in many of the buildings. The cantonment has been more affected than the city.

Earthquake Forms—Jullundur.

Mr. G. H. Hilton, Sub-Divisional Officer.—Two main shocks, the 2nd the more severe. Direction N.—S. or *vice versâ*. It was most severely felt. Cracks in buildings generally through arches and between junction of walls. Greatest damage to walls running E.—W., the cracks being from top to bottom. A rumbling sound as if mail train were passing over bridge.

Mr. M. W. Fenton, Deputy Commissioner.—One continuous vibration increasing to a maximum and decreasing again, with minor subsidiary vibrations throughout the day. He woke up and ran precipitately out of the house. Cracks in N. N. W. walls of house. Falls of masonry from arch. No sound noticed.

Lieutenant G. C. Hynes, 4th Gurkha Rifles.—One distinct shock followed by steady vibrations. Trees swung. Distinct rumbling sound after the first shock like surf on a distant beach, and continuing almost as long as the vibrations. First shock brought down much plaster, pictures, etc. Ponies very restive before the shock. All the birds were flying very high after the shock.

Amritsar.

Time observations.

One Railway station platform clock stopped at 6-8 A.M., but must evidently have been slow. All the other clocks also stopped, but opinions differed as to the exact minute at which they did so, although one observer seemed certain it was 6-15. A gentleman in the town recorded 6-15, but could not vouch for the accuracy of his watch. It seems likely that the railway clocks were about 5 minutes fast, and that the true time was 6-10 as at Lahore and Jullundur. It will be noticed that the aftershock recorded at Jullundur at 6-30 is recorded at Amritsar station at 6-35, probably by a watch which had coincided with the railway clocks before they stopped.

Number of shocks.

Two principal shocks close together were noticed by one observer, the first no doubt corresponding to the preliminary disturbance. According to the Railway authorities, there was a third at 6-35 A.M. and other slight tremors at 8-20 A.M., 8-57 A.M., 9-30 A.M., 10-40 A.M., and several during the night. At about 1 A.M. a very slight shock was noticed by several officers on night duty at the station, causing movement of a punkah.

Sound.

By most people an accompanying sound was heard, and is variously described as being like thunder, the firing of mus ketry, the rumbling of a train, etc.

Effect upon buildings: Railway station.

The direction of the line and the station buildings is E. 15° N. to W. 15° S. At the entrance, on the N. side, is a large and rather high porch with a flat roof, supported by beams at right angles to the main wall. These beams were apparently loosened in their sockets, and part of a parapet wall overlooking the porch fell upon the W. half of the roof, which consequently collapsed. The remaining half threatened also to fall, and was taken down.

A second-class waiting-room built out on the N. N. W. side of the platform buildings has separated from the latter by means of two opposite cracks in its side walls which run N. N. W., the cracks occurring close to the platform buildings. All arches and walls parallel to the line are unaffected.

Church.

On the N. side of the western porch of the Church is a moderately tall belfry steeple bearing at its summit a stone cross, which is fixed to the steeple by an iron core through its centre. The cross and upper 4 feet of the steeple have been wrenched away from the lower part of the latter, but have been prevented from falling by the iron core. This, however, has been bent from the vertical so that the cross and steeple top are now leaning exactly towards S. W. (fig. 42).

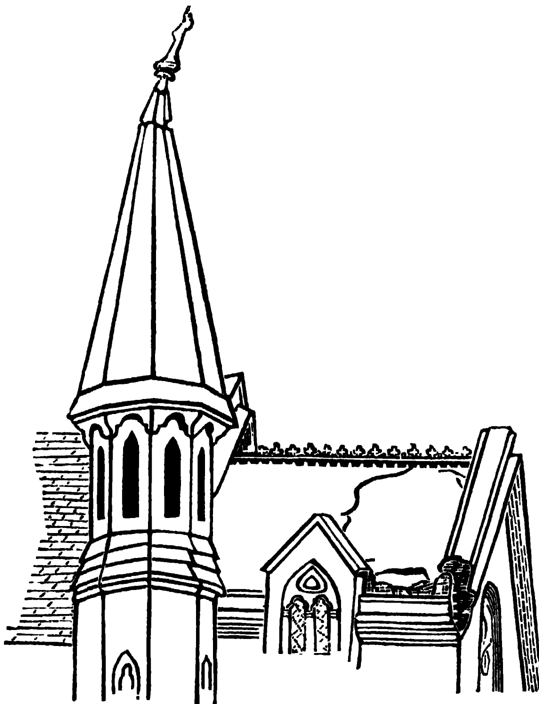


FIG. 42.

In the W. wall of the adjacent western porch, near the N. W. corner is a long wide crack running vertically downwards. The edge of the gabled porch roof at this corner has been shattered, and a little brickwork has fallen.

Inside is a conspicuous crack over the high chancel arch, and there are insignificant cracks over the aisle windows.

Post Office.

The Post Office is a rectangular red-brick building with its longer axis N. W. to S. E. Very slight cracks are distributed fairly equally over all the walls, especially over arches and in corners as usual. From the walls on the N. W. and S. E. project two porches, each carrying two small brick balls on the outer roof corners. In the case of the S. E. porch the two balls have been projected towards the N. E. and S. W., and have fallen one on each side of the porch; while the pair on the N. W. porch have not fallen but have been severely shaken and cracked.

Ram Bagh gateway.

The Ram Bagh garden gateway is an old square building standing N.—S. and E.—W., pierced by a large arched gateway entrance from the N. to the S. side. Each corner bears a large cupola supported by six slender pillars, each being strengthened with an iron core. The pillars of the S. E. cupola have been thrust over towards the S. W., the cupola and pillar-casing having fallen in this direction, leaving the deformed iron frame-work considerably bent towards the S. W. The S. W. cupola leans slightly towards the S. W.. the N. W. cupola towards the N., and the N. E. cupola towards the E., but it is uncertain whether this has resulted from the earthquake: the cupolas on the N. W and N. E. have four pillars each only. (See pl. 25.)

On the roof is a stone *baradari* which has been severely shaken and cracked and is now in an unsafe condition. The gateway is badly cracked all over.

Clerk's Memorial.

Clerk's Memorial is a small, red-brick house, in the shape of an octagon, two opposite sides of which are longer than the others: the longer axis points N. E. to S. W. A verandah extends for three-quarters of the distance round, the other quarter being occupied by a low "wing." A cornice on each of the two longer sides of the octagon has, in each case, fallen on to the roof of the verandah beneath, and broken the roof beams. At the S. W. end a similar cornice above the "wing" has fallen on to the underlying roof, and the cornice on the margin of *this* roof, together with a portion of the wall beneath, have fallen outwards towards

the S. W. The brickwork immediately beneath and just above a blocked up arch is shattered and has sagged at the centre, as if some force had been pulling the arch apart.

Serai.

Over the entrance gateway of the serai near the railway station are two cupolas, each on four pillars, the wall which they overlook pointing roughly N. E. to S. W. An iron core passes up each pillar and is bound to an iron frame-work investing the cupola. One of these cupolas has been thrust, from 6 inches to a foot, over the pillars, and is now leaning towards the S., but has been saved from falling by the grip of the iron bands.

Old Hotel.

The old Amritsar Hotel is a somewhat extensive building whose longer axis lies W. 10° N. At its W. end is a semi-circular verandah from which projects a porch consisting of 3 pillars connected with the verandah by 3 beams supporting the roof. The beams therefore run W. 10° N. and the southernmost one has been jerked out of its socket in the verandah wall and fallen, involving the S. half of the porch roof in its fall. The other two beams with their joists remain, and the solidly constructed verandah has escaped with a few insignificant cracks over the arches. The rooms inside are not seriously injured, although many show small cracks.

A small brick pillar-head fell off the top of the southernmost porch pillar in a direction S. 30° W.

New Hotel.

There are several long cracks in the new Amritsar Hotel especially in room corners, and the arches of the verandah on the W. are cracked in the usual way. The porch on the E. side of the house has separated by one or two inches from the wall, and is unsafe.

Divisional Court.

The Divisional Court has received several cracks, but no serious damage. The porch, as usual, is the chief part affected.

Mission Church.

A wooden belfry on the W. end of the Mission Church has fallen towards the N. W. on to the W. half of a gabled-porch roof beneath, through which it broke. The S. half of this roof is unbroken, its tiles being intact. There is nothing in the plan or symmetry of the building, or of the belfry, to have

caused the latter to fall towards the N. W., rather than towards the S. W.

Bungalows.

Several bungalows* have been very seriously damaged: four or five, including one three stories high, will have to be largely rebuilt. As at Jullundur, the tendency has been for the upper parts of walls to fall upon the roofs of verandahs or lower wings of the house. Repairs had masked most details of interest before they could be examined.

Amritsar City. Ram Bagh City Gate.

The N. parapet of the round massive bastion-like tower fell towards the N. In other places brick-work fell from high situations, the general direction being towards the S. or S.W. One room in an upper story contained two oblique cracks, one in each of two opposite walls running N. 30° E. The cracks were fairly straight and haded towards the S. W., making an angle of 40° with the vertical. There were no windows nor doorways in these walls to affect the direction of the cracks.

Clock Tower.

The Clock Tower (see fig. 43) is a modern structure of red-brick, covering a small area, but 175 feet high. A central iron core runs through the upper part of the lofty steeple, and carries a weather-vane. Three uneven horizontal cracks have split the upper 8 eet or so into three portions. The uppermost portion still encircles the iron core, the middle portion has, as far as could be judged from below, taken the place of the lowest portion, which has been thrown down towards the S. E. The middle portion has been much shaken about and now rests a little to the N. of the core. The indicator of the weather-vane has been twisted round through 45°, so that the N. pointer points towards the N.E. The central steeple is the only part which has suffered.

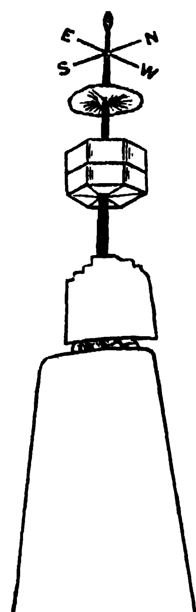


Fig. 43.

Golden Temple.

The Golden Temple, close to the clock, and surrounded by a large water-tank, has sustained no injury, in spite of the numerous and delicate pinnacles present.

Mosque of Sheikh Din.

At the four corners of the sanctuary of the mosque of Sheikh Din whose longer axis points N. and S., were four minarets rising about 6 feet above the roof, each having an iron core running down its centre, and being crowned with the customary cupola and pillars. Of these minarets, that on the S. E. is leaning away from the centre of the sanctuary towards the S. S. E.; the cupola and pillars of the S. W. one have been thrown off, as far as could be made out, towards the S. W. The remaining two have been snapped across about half way between the roof and the summit, and the upper parts have fallen; the dèbris had been cleared away before the mosque was examined, but the direction of fall is indicated by small projecting portions of the iron core which had broken in each case; each of these portions is now bent, in the case of the N. W. minaret, towards W. S. W., and in the case of the N. E. minaret towards N. W.

Ram Garhien Bunga.

The walls of the court extend N. W. to S. E. and N. E. to S. W., and at the S. and E. corners are two high minars crowned with the usual pillars and cupola, much resembling those of Wazir Khan's mosque at Lahore. In both cases the cupolas and pillars have been severely shaken, and small pieces have fallen. The E. minar is now leaning towards the N., the S. minar remaining vertical.

Bazar.

In the bazar the general direction of shock indicated by the majority of fractures and falls is N. E. to S. W. In at least two cases the disturbance appears to have travelled from S. E. to N. W. or *vice versâ.* The testimony of bazar buildings, however, is usually too much complicated by irregularity of design and inferiority of material to be of much value. In four cases walls of houses have either wholly or partially fallen; in two cases walls pointing N. W. to S. E. have separated widely from the rest of the building, and in one case a parapet wall has fallen.

Water in an elliptical bath lying with its major axis N. and S. was seen splashing out at the N. and S. ends.

Intensity and direction.

Near the Railway platform, raised some 15 or 20 feet above the ground, is a large rectangular iron tank whose longer axis lies E. 15° N. to W. 15° S. Directly after the shock two observers noticed that water was being thrown out over the longer sides, and that more came over the western than over the eastern corner of the S. side. The intensity appears to have been equal to that at Jullundur.

Summarising the evidence as to Direction of Shock we have as follows:—

Church.—From N. E.

Ram Bagh gateway.—From N. E.

Clerks' Memorial.—From S. E. and N. E.

Serai.—From N.

Old Amritsar Hotel.—From N. E.

Mission Church.—From S. E.

Ram Bagh City Gate.—From N. E.

Clock Tower.—From S. E. (?).

Railway tank.—Approximately from N.

Earthquake Forms—Amritsar.

Mr. E. L. Crawford, Assistant Engineer.—The first shock increased in strength until the end. There was then an interval of about 2 mins. and then followed a second shock. Direction E.—W. by the swaying of a tree. No sound. The ground actually moved. Nausea was produced. House damage irregular. All arches cracked.

Mr. A. H. Johnston, Asst. Engineer.—Time 6-10 A.M. by watch timed at railway station. There was one prolonged shock, severe. Direction N.—S. by cracks in wall and hanging lamp.

Mr. J. F. Pereira, Telegraph Master.—(1st) there were slight tremors increasing for 30 secs., (2nd) the great shock lasting for 1½ mins.; (3rd) several tremors. The cot moved violently. He rushed outside immediately. Nausea and giddy feeling felt by wife and daughter. The shock was very severe. Houses rocked violently S. E.—N. W. Walls parallel to S. E.—N. W. were damaged owing to differential movement, whereas opposite walls simply rocked on their bases and either toppled over or sustained no damage. A low rumbling sound preceded the first shock,

coming from S. E.—N. W. The whole ground heaved like waves of the sea. [The writer, who has evidently studied the subject, makes some further remarks as to the origin of the shock, which, however, have been disproved by actual traverses over the ground.]

The Postmaster, Townhall.—Time 6-10. Duration 1 min. 58 secs. Very severe. Nine people killed and much damage.

Mr. J. Ashford, Supdt., Central Workshop, Irrigation Department.—Tremulous vibrations, 200 per minute. Direction E. by N.—W. by S. Direction obtained from oscillating chimney. The shock was violently felt, all doors and windows rattled violently and some came unbolted in consequence of the upper bolts dropping down, and doors opened. Ornaments fell. Two pendulum office clocks stopped at 6-11 on wall facing E. They were regularly checked by railway time. Many buildings damaged on E. and W. sides. Violent shaking of the bed in which he was. He ran outside. The sound was a distinct rumbling.

Mr. G. W. E. Atkinson, Assistant Secretary to the Municipality.—One continuous shock, 40 to 50 seconds. Hotel buildings swayed from side to side, also up and down in a confused way. Direction uncertain. Doors rattled. He was aroused from sleep, and immediately went outside. The most severe shock he has felt in his life. If it had lasted twice as long he thinks all buildings would have collapsed. Isolated houses have suffered more than groups which buttressed each other. Tall factory chimneys did not suffer, nor railways, nor bridges.

Mr. F. W. Schonemann, Executive Engineer, Bari Doab Canal.—There was first a banging and rattling of doors followed immediately by a rumbling noise like a carriage or cart driven round the house on hard ground. Second a prolonged steady reciprocating motion of horizontal jerks for about 10 secs. Third a regular oscillation for more than 3 minutes. Direction N.—S. by hanging fern baskets. At 4 A.M. his wife heard a door rattle. Also Mr. Roberts in the same house heard it and thought it was thieves. (See Foreshocks, p. 355.)

Tarn Taran.

This large village is situated 14 miles south of Amritsar.

Tehsil.

A wall in the high two-storied entrance gateway of the Tehsil building was dangerously cracked and had to be taken down. Several arches inside the Tehsil are cracked, and the E. porch of the Treasury was so severely shattered as to necessitate its removal.

Golden Temple.

The injury to the temple is practically confined to the roof on which is built a *baradari*, consisting of four corner pillars of L-shaped section and eight intermediate pillars of rectangular section, the whole forming twelve arched doorways

supporting a square domed roof. Upon the centre of the latter was a large cupola of gilt brass: smaller similar cupolas were borne by low turrets at the corners and along the E. border. Most of the roof with the large cupola collapsed, but failed to break through the temple roof, which was fortunate, as the sanctuary below was densely crowded with Sikhs.

The Town.

Out of 1,400 houses in the town, the majority are cracked, 150 seriously enough to require repairing, while in the case of 5 or 6, portions have fallen. The greatest damage was done to the rather high *bungas* on the N. side of the enormous tank of the temple. The wall facing the tank, *i.e.*, standing due E. and W., fell outwards from four of the *bungas*, killing 9 and injuring 7 men.

Ferozepur.

Time Observations.

The time recorded by the Telegraph Master by the office clock which had been corrected by wire from Madras the previous day, was 6-12 A.M. No time observation was taken at the post office.

A few observers (see Earthquake Forms) record 6-10 by ordinary watches which were said to be fairly correct.

Effect upon buildings.

The Post Office.

The Post Office itself is uninjured. Two rooms in the Postmaster's private quarters show cracks over the window arches and a few slight ones in corners or between the walls and roofs.

The Mission Church.

There is an irregular crack in one wall of the Mission Church and the steeple has rocked, causing a slight loosening of the brickwork all round.

The Government School.

The school is a large one-storied building, divided by three principal partition walls, all running E. 30° N. to W. 30° S. Each partition wall contains four bricked-up arches, the bricks of which have fallen or project on one side or the other.

There are serious cracks in the corners of the rooms especially near the roof.

The Fort.

The Garrison Gunners' barrack is a two-storied red-brick building whose longer axis lies N. 35° E. On the upper floor arches running in this direction on each side are severely cracked, those at right angles are also cracked but to a smaller extent. The outer verandah wall and part of the roof on the S.W. was so badly cracked and shaken that reconstruction was necessary. Arches in the ground floor are affected in an exactly similar way but in a smaller degree.

Other barracks were slightly cracked, but showed nothing of interest; and flights of stone steps scaling a long artificial bank in several places were cracked transversely.

Bungalows.

The following summary of the damage done to bungalows may facilitate a comparison between the intensity at Ferozepur and that at Jullundur: the bungalows in the former town are not so uniform in size and plan as they are in the latter.

In the Deputy Commissioner's bungalow there are a few slight cracks in the corners of rooms and over windows. The porch has separated a little from the house, and pillars in the verandah are cracked horizontally all round the base.

The travellers' bungalow shows a few cracks in corners and above windows, but no appreciable injury.

In bungalow No.—, in one room, the walls which as usual were not bonded together have separated, producing a crack from floor to ceiling in each corner. Cracks seemed to predominate in E. to W. walls. A few bricks dropped from a pillar of the porch, and the arches in the latter were cracked.

In No. 50, the brickwork of three chimneys was shaken loose, and had to be rebuilt: the walls contain several cracks.

In No. 48, there are several conspicuous cracks, especially in walls running N. and S., and two or three chimneys have been shattered.

In No.—, walls running E. and W. are badly cracked, in some places from floor to roof. The N. to S. walls were either entirely devoid of cracks or contained a few slight ones.

No. 40 had a thatched gable roof, inclined towards the E. and W., on which were four rectangular brick chimneys. In all thatched roofs observed it was noticeable that, owing partly to the insecure means of attachment to the roof, and partly to the steepness of the slope of the latter, chimneys were very liable to fall bodily. One of the stacks of this bungalow has all but fallen, and is now balanced on one of its lower outer corners, leaning in the direction W. 30° S. A second has been completely overthrown, and the remaining two have been badly shaken.

In No. 26, there is a large crack in the front verandah, and two chimneys badly cracked at the base have been rebuilt.

In No. 17, two chimneys on the thatched roof have fallen and in No. 10, one chimney on the thatched roof has fallen.

In the Chemist's bungalow, a small section of the roof-margin of a somewhat insecure-looking porch has fallen.

In No.—, a wall on the W. side of the house has fallen upon the verandah roof.

Royal Artillery Lines.

Two of the barracks of the Royal Artillery Lines which consist of the usual long two-storied red brick structures, and whose longer axes point N. E. to S. W., have been affected in an exactly similar manner. On the upper floor, all arches and doorways running transversely, *i.e.*, N. W. to S. E., are cracked, in a few cases seriously, especially those traversing the verandah. Some longitudinal arches and doorways show cracks, but these are smaller and less numerous; many of the longitudinal arches of the outer verandah wall even have escaped, although these are generally points of weakness. The condition of the ground floor is an exact repetition on a smaller scale of that of the upper floor.

In a third barrack whose bearings are the same as the first two, a somewhat similar thing has happened, but the injury is greater. There are wide cracks in transverse arches and doorways but the longitudinal arches are much less gravely affected. The outside transverse

walls at each end of the building have been fractured so badly as to become dangerous; the upper story portion is being dismantled and rebuilt.

The Quarter Guard.

This is a smaller building, rectangular in plan, pointing N. E. to S. W. It carries a gable roof with three square chimney-stacks along the N. W. margin, and around it runs a verandah with a flat roof. A small corner of the chimney at the N. angle has fallen towards the N. on to the verandah roof below. At the S. and E. corners, small portions of the wall and roof fell on the verandah roof.

N. Staffordshire Lines.

In barracks No. 2, the tops of two chimneys have fallen, as far as could be seen, towards the N. E. or N. The conical cover of a small iron chimney is said to have been bent by the shock, and is now directed towards the E. N. E.

Hospital Church.

In the station hospital a few small cracks occur over arches indiscriminately.

The ornamental parapet of a gable of the church has been taken down, because of serious fracture.

Ferozepur City.

Little damage has been done in the city, and nothing of any interest has happened.

The arch of the city gate runs east to west; a vertical crack passes right through the building from back to front, at the side of the archway.

In the mosque of Munshi Faiz Bakhsh, and also in another mosque, a small minaret has fallen towards the west.

A portion of the east wall of a tall three-storied house has fallen from the highest story outwards towards the east and has broken through the roof of an outhouse below. In the remaining portion of this wall is a wide crack extending from the roof to the ground.

Direction and intensity.

Three observers at the Fort felt the shock come from N. to S., and according to one it was not easy to keep one's balance.

The Assistant Telegraph Master noticed a square chimney-stack rocking apparently in a N. to S. direction, and also, while the shock was in progress, observed water, in round fire buckets, standing in the compound, being splashed over the sides on the N. E. and S. W.

The majority of buildings possess some cracks, but these are usually slight, and no great injury has been sustained. There are several buildings which show no trace whatever of the disturbance, and some two-storied houses in the city appear to be free from any but slight cracks. It is evident that the shock was less intense here than at either Amritsar, Jullundur or Lahore.

Summarising the evidence as to direction of shock we have :—

Government School.—Approximately from N. E.

Fort.—Approximately from N. E.

Bungalow No. 40.—From E. 30° N.

R. A. Barracks.—Approximately from S. E.

North Staffordshire Barracks.—From E. N. E.

Earthquake Forms—Ferozepur.

Major J. R. Adie, Civil Surgeon.—Time 6-10 A.M. by watch generally correct.

Bakhshi Ram Singh, Executive Engineer, Provincial Division.—Time 6-15 A.M. by clock compared with gun at 12 o'clock. One principal shock of 2 minutes duration. No tremulous vibrations afterwards noticed. Direction N.—S. by hanging lamp. Ornamental piece of chinaware fell from fireplace towards W. Cracks in arches S. W.—N. E. generally.

Fateh Shah Khan, Head Clerk, Executive Engineer.—Time 6-10 by timepiece regulated by gun fire. There were 1st no preliminary tremors, 2nd incessant shocks for 1 minute, 3rd tremors for 3 minutes. Trees shook, and houses separated at corners. Direction N.—S. by trees. It disturbed the balance of people. A lamp fell. Sound like underground thunder.

Mr. A. G. Savedra, Telegraph Master.—Time 6-12 A.M. by telegraph clock and private pendulum clock, both of which stopped at this hour. First a continuous trembling vibration for 30 seconds. One prominent shock lasting 60 seconds which increased and diminished regularly. Third no tremulous vibrations afterwards. Direction N. W.—S. E. It was a horizontal shock only, not as at Shillong in June 1897 which was also undulating. No sound.

Wazirabad.

Mr. Pascoe's observations continue :—

Time. In the Post and Telegraph Office no clocks stopped. The time was thought to be 6-10, but this is unreliable, even supposing the clocks were correct. At the Railway Station also no clocks stopped, and no time was recorded in the Telegraph Office. The Stationmaster recorded by his watch 6-10 A.M., but the clock in his bungalow stopped at 6-15. Both watch and clock are stated to have been correct.

Number of shocks. After the severe wave, slighter shocks are said to have occurred approximately at 6-50 and 7-10 A.M. The latter shock was more noticeable than the former.

Effect upon buildings. There was nothing of much interest to be seen in the buildings; the following is a brief summary of the damage inflicted :—

The Tehsildar's house, a two-storied one, has cracks, especially in the walls running N. and S.; one crack stretching from roof to base. The S. wall of the top story has separated a little from the remainder.

In four rooms in the Police station cracks were more frequent in walls running N. to S. than in those running E. to W. Two small rooms of different height built side by side on the roof, and lying E. and W. of each other, have separated a little from each other near their common wall.

House (1) is three-storied and very irregular. A wide crack extends from the roof to the arch of a window in the N. wall. House (2) is an infirm-looking structure and badly cracked. In house (3) a very badly built wall has fallen.

House (4) is two-storied, and moderately well built. It has suffered more heavily. The S. wall of the upper and part of that of the lower story have fallen, together with the E. wall of the upper story and the roof.

In house (5) the N. wall of the upper story has fallen outwards towards the N. In house (6), a one-storied house, the west wall fell outwards towards the W.

In house (7), a wall fell from the third story and smashed a roof below. In house (8), the whole upper story has fallen.

House (9) is an old, badly built, three-storied building, with a lower outstanding portion which has separated widely owing to the difference in the period of vibration. A wall fell from the third story, struck a house opposite and brought part of its wall down also. A second wall is severely cracked, and what remains of the house is in a very dangerous condition.

The direction of a tall blocked-up gateway of red brick, carrying a parapet wall, is E. and W.[1] At the ends of the parapet, on the front corners of the gateway, are two brick towers. The E. tower and nearly all the parapet has fallen outwards towards the S. Part of the E. wall near the S. corner has fallen, and also a portion of a wall from 25 to 30 feet high, extending E. and W. from the gateway.

Direction and Intensity.

In the Stationmaster's drawing-room, an ornament on a shelf in the E. wall fell on to the floor towards the W. A glass vase on the mantelpiece (direction N. W. to S. E.) in the S. W. corner of the room was thrown over to the N.W. : the vase was unbroken.

There are many lofty buildings in the bazar; houses of two or three stories are quite common, and many of these have been unaffected by the earthquake. In spite of the number of native houses which have suffered seriously, the intensity appears to have been hardly any greater than it was at Ferozepur, due allowance being made for the previously almost ruinous state of many of the Wazirabad dwellings.

Gujranwala.

Time observations.

No clocks stopped at the telegraph office, but the time noted is said to have been 6-10 A.M. The time is wired daily from Lahore. The time noted by the

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1 *i.e.*, the direction of the arch.

Postmaster, according to the office clock, was 6-10 A.M. At the American Mission, a clock, believed to be correct with Railway time, stopped at 6-12.

Number of shocks.

Two severe shocks are spoken of, the second being the longer of the two. Others were felt subsequently.

Sound.

A noise like that of a carriage passing along the road was heard.

At the Deputy Commissioner's bungalow in the office—a room built out separately from the house—there are two opposite wide cracks in the W. and E. walls near the corners made with the N. wall, and there is a corresponding crack in the roof. It is clear that the N. end of the room tended to separate from the rest. An old decorated room upstairs has several ornamental arches cracked.

Effect upon building.

Gujranwala City.

The tomb of Máhan Singh is a tall octagonal structure with a series of eight solid cupolas at one stage of its height, one at each corner of the octagon. The two on the S. side of the octagon are bent over, and now lean towards E. 15° N., their iron cores having prevented them from falling.

In the temple over the sanctuary entrance were two small minarets rising about 12 feet above the roof. A small knob on the summits of the cupola of the S. minaret fell westwards on to the roof of the sanctuary, about 6 feet away from the minar; the cupola-knob of the N. minaret fell eastwards into the court below (no mark on the ground could be found), and the cupola itself fell westwards on to the sanctuary roof.

The roof of a tall two-roomed barn, 20 feet high, has fallen, together with the inside partition-wall and the whole of one of the walls at right angle to this. The material was of burnt brick with poor cement. There has been relative movement between two contiguous houses lying W. N. W. and E. S. E. of each other. One of them has shifted outwards towards the street in a N. N. E. direction, and now projects considerably from the other house.

In another two-storied house, a kucha wall has fallen outwards.

At the American Mission, a lamp hanging by a rod 16 feet long from a ceiling 23 feet above the ground was observed to swing through an arc whose chord was equal to 2 feet. The direction of swing was N. E. to S. W.

Direction and intensity.

The intensity was equal to that at Wazirabad.

Earthquake Forms—Gujranwala.

Mr. A. Murphy, Assistant Engineer, Upper Chenab Canal.—Time 6-13 at the end of the main shock by watch set the previous day by the railway station. One main shock, 3 vibrations felt afterwards in 20 minutes lasting each only a few seconds. Direction N. N. W.—S. S. E. by water in a tank. Distinctly felt. Difficult to stand outside without support. Motion like a row boat in the wash of a steamer. A few badly built old houses fell. Cracks in a large proportion. Sound sharp and rattling which seemed to come from the N. and die away to the S.

Mr. G. C. Laurie, Executive Engineer, Chenab Canal.—Time 6-10 about. He was in bed in a tent. There were 1st several short preliminary shocks, 2nd one main shock which lasted for some time, 3rd several tremulous vibrations. It was very intensely felt. He held on to the side bamboo of tent which was moving very considerably. Slight cracks in Sessions House. Many houses in city cracked and some fell.

Fazl Elahi, Head Signaller.—Time 6-10 A.M. by office clock keeping standard time (*i.e.*, at that time Madras time). Distinctly felt and damaged nearly all the public buildings by cracks. Nothing overturned in the telegraph office.

Gujrat.

Mr. Pascoe's observations continued :—

The time observed by the Stationmaster, who was in his office at the moment, was 6-13 A.M. The time is wired daily from Lalla Musa which receives its times from Lahore. The duration is said to have been 4 minutes.

Time observations.

The Stationmaster observed water moving in circular fire-buckets in a direction E. N. E. to W. S. W.: none splashed over the sides, however, although the water was within two inches of the brim.

Direction and intensity.

The town is about the same size as Wazirabad, the populations being equal. About 20 houses need serious repair. No house fell immediately after the shock, but on the day following, a house which had been severely shaken collapsed, and killed a boy.

Earthquake Form—Gujrat.

Mahomed Hamedulla Khan, Postmaster.—Three shocks, the 2nd the most intense with a few seconds interval. First doors and windows trembled, 2nd the 3 shocks as above, 3rd tremulous vibrations afterwards for not more than 3 minutes. The sound "felt" like "shau" "shau" 2 or 3 seconds after the 1st shock. Cracks in the postmaster's quarters.

Sialkot.

Time observations.

One observer records 6-10 by his watch which was correct. (Probably according to the daily gun.) The clock at the post office stopped at 6-10; this is corrected by the gun. The clock at the telegraph office stopped at some time between 6-13 and 6-16, but the exact time was unobserved.

Number of shocks.

After the great shock, three slighter ones are reported to have been felt during the 20 minutes following. One was also noticed at 11-30 A.M. and another about 12 P.M.

Effect upon buildings. English Church.

A stone cross fell from the top of a tall steeple of the English Church at the N. W. corner and struck the ground, making three dents in the latter, the line joining the dents pointing towards the centre of the steeple, and the middle dent probably corresponding to the centre of gravity of the cross. The latter had been fixed to the steeple by an iron core which snapped at the base of the cross.

Direction in which cross fell = W. 15° S.

Height of steeple from base of cross to ground (as measured by an Abney's Level) =167½ ft.

Height of cross = 4 ft.

Distance of middle dent from the centre of the square base of the steeple = 41 ft.

From these figures, the horizontal velocity of the cross works out to be 12·7 ft. per second.

The steeple like the rest of the church is of brick, and about 16 feet below the apex, a horizontal crack extends all round. [Query—Is this where the iron core ends?] Inside the church there are several cracks above the arches, but these are not serious: a rather more conspicuous crack occurs over the circular window in the W. wall, another over the doorway.

Roman Catholic Church.

At the W. end of the R. C. Church is a square embattled tower, whose bearings are N. 10° W. to S. 10° E. by E. 10° N. to W. 10° S. Within the corners of the roof of this tower were four small turrets; the two on the E. have fallen and fractured the corner battlements especially that on the N. E. The N. W. turret was leaning out of the perpendicular and part of the corner battlement had fallen. The S. W. turret was intact, but a small part of the brickwork under this battlement was missing. In short the corners of the tower have been affected, whilst the intermediate battlements with one exception on the N. are as they were previously.

Inside are a few small cracks over arches.

The Military Prison.

A chimney has partly fallen from the Military prison, and verandah arches are cracked in many cases. Some old cracks in the N. to S. wall of the main corridor have been quite unaffected.

The Infirmary Hospital.

A transverse partition wall in the Infirmary—direction N. 35° W. to S. 35° E.—has three very bad cracks, one over the side of the arched doorway, and two extending from floor to roof beside the chimney flue. This wall required dismantling.

Barracks.

The British Infantry, the Cavalry, and the Royal Horse Artillery barracks, all show small cracks. They are solidly built, with thick walls, and have sustained little damage.

Some of the Cantonment bungalows were badly cracked.

Sialkot City.

Each of two small cylindrical minarets standing over the entrance gateway of the mosque shewed a conspicuous vertical crack. The direction of the gateway was N. E. to S. W., and the direction of the planes in which the cracks lay was in both cases N. N. E. to S. S. W., the shock apparently having struck the mosque from the E. S. E.

House (i), two-storied—burnt brick with plaster. The N. wall of the upper story throughout the length of three rooms fallen out, and there is a very wide crack in the side wall. House (ii), one-storied. Has fallen down. House (iii), rudely built, with thin walls. Has fallen. House (iv), two-storied—dangerously cracked. House (v), has four stories and an attic. Upper story cracked. House (vi), four-storied. Upper story dangerously cracked and partly fallen. House (vii), two-storied. Upper story fell. There were several three-storied and some four-storied houses in the bazar. All these were cracked in the upper stories at least. Some loose bricks fell from N.—S. wall 12 ft. high, but none from a similar E.—W. wall.

Direction and Intensity.

A lamp hanging in a bedroom by an iron rod about 12 feet long was seen by one observer to swing somewhat obliquely across a room, through an arc of about 2 feet. The path described, however, was not a straight line but a very much elongated ellipse whose major axis pointed W. 30° N. and E. 30° S.

A second observer describes a lamp swinging from a similar iron rod in a direction N. 20° W. to S. 20° E., the path being a straight line as far as could be seen.

A lamp in the Military prison was seen to swing E. to W.

The covers of four telegraph instruments in telegraph office fell off towards the W. on to the tables. These covers were so placed on the sides of the instruments that no moderate shock except one from approximately E. or W. could have dislodged them. A violent shock from the N. E., S. W., N. W., or S. E. might have done so, but a shock from the N. or S. would almost certainly have left them in place.

In the Telegraph Master's private quarters, a lamp was seen to swing due E. and W. as far as can be remembered.

Nearly all the houses in the city are cracked: one has completely fallen, and about six partly fallen. Burnt brick buildings were said to have suffered more than those of sun-dried brick, but stability of structure depends as much upon the cement as upon the brick used. The intensity was greater than at Wazirabad, and appears to have almost equalled that at Lahore.

Earthquake Forms—Sialkot.

Mr. J. F. Kennegy, Telegraph Master.—Time about 6-12 A.M. Office clock stopped at 6-15. One smart and continuous tremor, no separate shocks. Doors rattled loudly. House rocked for a few seconds. Direction E.—W. by hanging lamp. Distinctly felt. Light zinc covers of the telegraph instruments 4″ by 3½″ by 2″ tilted on one side of the instruments. Walls slightly cracked. Rumbling sound during main shock.

Mr. Carl H. H. Müller, Executive Engineer, Upper Chenab Canal.—Time 6-10 by watch set by railway time. One severe shock for one minute, 3 or 4 other shocks. Direction E.—W. Bed moved. He was first awakened by a sound like wind. There was a rolling movement like a boat at sea. Plaster fell from walls. Walls cracked, roof groaned, trees swayed and birds flew round and dogs barked. Ponies restless and neighing. He felt nausea.

Jammu.

Time observations.

At the post office the time was stated to have been about 6-13 A.M., duration about two minutes. According to another observer, 6-5 was recorded by a clock said to have been keeping Madras time: duration two-and-a-half minutes.

Number of shocks.

Two distinct shocks are reported, the second the stronger of the two. Continuous tremors followed the main shock for more than 20 minutes as indicated by the vibration of a key-ring suspended on a knife-edge: these tremors were not otherwise perceptible. Slight shocks occurred subsequently during the day: one at 4-30 P.M. lasting for about fifteen seconds.

Sound.

A rumbling noise is described as having been heard; but for a short time only.

Effect upon buildings: Post Office.

The post office is intact, but the adjoining Postmaster's private quarters are cracked in several places.

The principal gate of the Governor's Palace is severely cracked at the four corners. Some staircases are said to be dangerously fractured, and there are many small cracks in the various buildings. A brick pillar at the corner of a parapet on the third floor roof fell towards the E. into the Palace yard.

Governor's Palace.

The Governor's offices, a tall building of three or four stories, is quite unaffected, and the State school also, an extensive building, is practically intact.

Offices: school.

A large two-storied building forming the rest-house has the lower story apparently unaffected, but the upper is seriously cracked, especially in corners and over arches. The cracks are larger and more frequent in arches and wall lying W. 15° N. The bungalow is declared to be unsafe and is closed.

The rest-house.

A large lofty red brick building, the Palace of Ramnagar, built in the English style and on an eminence, has a few slight cracks.

Palace of Ramnagar.

A solidly constructed rampart is cracked and part has fallen. The upper portion of a gateway arching from N. 30° E. to S. 30° W. has fallen towards the E. The material consists of large moraine pebbles cemented together. Walls have fallen in the case of 7 houses in the bazar, but nearly all these were two-storied dwellings: many houses are cracked but no very serious damage has been done.

The movement appeared to be from E. S. E. to W. N. W. A clerk in the Mining Office, sitting upon the floor and facing E. S. E., was thrown flat upon his back. Water in tanks is reported to have moved also in the direction E. S. E. and W. N. W.

Direction and intensity.

Although the inhabitants of Jammu described the shock as being a very severe one, the intensity, estimated from the effect upon buildings, is surprisingly less than at Sialkot, 26 miles away. Possibly this is due to the fact that Jammu is situated upon a low hill of boulder graved while Sialkot lies upon the flat alluvial plain. The intensity does not appear to have been greater than that at Ferozepur.

Earthquake Forms—Jammu.

Mr. J. Godwin, Mining Officer.—He was indoors on 3rd floor of house. There were first tremulous vibrations for 2 seconds (guessed), next 6 principal and most violent shocks lasting 2½ minutes with intervals of about 8 to 10 seconds. Thirdly, tremulous vibrations continued for more than 20 minutes after principal shocks. Direction E. S. E. and W. N. W., ascertained by suspending ring of bunch of keys attached to door frame. Sound, 1st a rumbling, 2nd "whizzing" when the movements were violent. Almost all buildings have received more or less damage. Tank water moved E. S. E.—W. N. W.

Bakshi Chandulal Sitaram, Divisional Engineer, Public Works Department. —The first shock was horizontal and undulating, continued for about 2½ minutes. Secondly, there were more shocks at small intervals much weaker in intensity and duration. Direction N. E.—S. W. from tank movement and cracks in buildings. Sound a continuous, dull, smothered sound. Universal alarm. At the first shock he was thrown S. W. On a repetition of it he went into the open air. Could not stand outside. Had to sit down. The sensation was as if at sea in an open boat. Metalled city roads badly damaged by upper layers of metal crumbling. The writer gives a long account of damage to walls of buildings, chiefly cracks and fissures, but some walls were overthrown. Estimated damage, Rs. 1,04,500. The following general results were ascertained :—(1) Houses built of boulder stone masonry suffered most. (2) Brick houses almost untouched. (3) Many-storied houses suffered more than single-storied.

Ludhiana.

Time observations.

One observer noted 6-10 immediately, by a watch keeping Madras time; this was confirmed by the stopping of two clocks at the same time.

Another observer records 6-5 or 6-6 by his watch which had been corrected by the daily gun.

A clock correct according to railway time, in a bungalow belonging to the American Mission, stopped at 6-5 A.M.

Effect upon buildings: the Post Office.

A curved verandah on the S. of the post office building shows a few wide cracks, and a small portion of it has fallen.

The Postmaster's private quarters, however, have suffered severely. From the margin of a chamber built upon the roof, a very heavy cornice fell, broke the beams of the roof, and brought a large part of the latter down, wrecking a room below. Two rooms on the roof had to be dismantled as the walls were dangerously out of the vertical.

Another room below has a very bad crack in one wall.

Fort.

The Fort is an old building, dating from the time of Ranjit Singh, situated on rising gound, its longer axis pointing N. 30° E. and S. 30° W. The roof is low, heavy and vaulted, the vaults being upheld by massive pillars. There are several wide cracks in the roof, one admitting daylight; all of them are parallel to the longer axis.

All the door and window arches on the second story of the officers' quarters, which are also old, have been cracked; the ground floor is practically intact.

Church: Dak Bungalow: District Engineer's Bungalow.

The Church is uninjured except for the loss of a few slates. The dak bungalow has a few cracks, but these are unimportant. In the District Engineer's bungalow, a chimney fell and cracked the verandah roof: a gate-post showed many cracks.

Court House.

The direction of the longer axis of the Court House is E. to W. There are very bad cracks in the verandah, and the upper parts of the walls are cracked, but the cracks traverse the mortar and not the bricks. Cracks in the rooms are more frequent in the walls running N. and S.

The Treasury.

The Treasury building itself is intact. The outer court is enclosed by four high walls with a projecting imitation round "tower" at each corner. These towers are floorless, roof-less, and the walls are incomplete on the inside. All four are cracked down the centre, while the walls connecting them are immune.

The Town Hall.

The Town Hall, a large capacious building, has escaped almost entirely.

The American Mission.

In the principal bungalow of the American Mission, a house of two stories, there are slight cracks above the verandah arches on the ground-floor, and larger ones in the same position on the upper floor. There are several cracks in walls and corners, especially in the upper story and especially on the N. side of the house, where the verandah is situated.

Wells.

A well in the fort, 20 feet deep, is cracked slightly in the portion above ground: below this there is no damage whatever. The same thing applies to a well in the Tehsil Courtyard. This rises 2 feet above the ground, and is traversed horizontally by a crack about 1 foot below the ground level.

Mosque (i).

This is built of burnt brick. Two minarets, rising originally 12 feet from the front angles of the sanctuary roof, were snapped at the roof level and fell into the courtyard below. The directions of fall, indicated by the repaired courtyard pavement, were in the case of the N. minaret E. 18° S. and in the case of the S. minaret E. 10° S.

Mosque (ii).

Two small minarets over the sanctuary entrance, rising 2½ feet above the roof, fell towards the W. on to the roof. Rather curiously, two larger minarets at the front corners of the sanctuary, rising 4 feet from the roof, did not fall.

The Bazar.

From five to six houses in the bazar are in a dangerous condition, either on account of leaning walls or large cracks, and some of these are old buildings and were more or less unsafe before the earthquake. Very little has fallen. Burnt brick buildings were said to have suffered more than sun-dried brick buildings.

Direction and intensity.

An observer sleeping in a single-poled tent near Ludhiana noticed the pole oscillating in the direction N. N. W. to S. S. E.: an ordinary rectangular based medicine bottle standing with its longer base axis N. E. to S. W. fell towards the S.E.

The first shock is described as having been felt from S. S. E. to N. N. W. and the second from E. S. E. to W. N. W. A hanging lamp was found swinging in an ellipse whose major axis was about 9 inches.

The intensity here may be estimated to have been a little less than at Lahore.

Earthquake Forms—Ludhiana.

Mr. C. J. Hennessey, Postmaster.—Time 6-4 telegraph time.—First there were 2 shocks, or rather the direction seemed to change from N.—S. to E.—W., the first

shock being of greater intensity. Second, vibrations continued for 1 minute after. Small articles on shelves were thrown to the ground. Walls rocked like the sides of a vessel in a storm. Beams collapsed and broke in two. N. and S. sides of buildings suffered. Clock pendulums swinging N.—S., also those swinging E.—W., stopped respectively at 6-6 and 6-8 A.M.

Mr. J. N. Gillman, Executive Engineer, Sirhind Canal.—Time 6-10 A.M. House rocked W.—E. Thumping on doors facing E. and W. of 3 minutes' duration. Pictures facing N. or S. swung like pendulums E. and W. Cracks in walls.

Mr. G. W. Maflin, Assistant Engineer.—Time 6-5 by watch. Two chief shocks and then tremulous vibrations for 2 minutes. First shock W.—E, 2nd shock S.—N. He gives an excellent elevation sketch of a mosque the minarets of which fell. (See fig. 44.) Booming sound during vibrations.

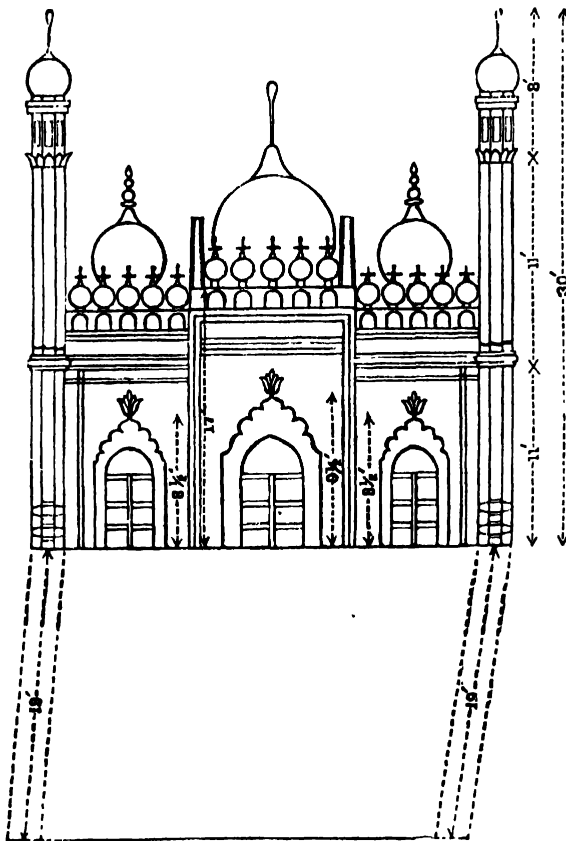


FIG. 44.

Mr. R. L. Bonnaud, Punjab Educational Department (retired).—Time 6-10 A.M. by watch showing Madras time, also by the stoppage of two clocks. There were 1st no preliminary tremors, 2nd 2 shocks, the 1st undulatory and the 2nd like a push or thrust in a W. direction, with intermediately violent vibrations too rapid to be counted, as if the house were a box shaken to and fro by giant hands, 3rd tremulous vibrations afterwards for 2 to 2½ minutes. Direction of the 1st shock S. S. E.—N. N. W. that of the 2nd being E. S. E.—W. N. W., judging by sensations and by movements of hanging lamp and water in tub. Felt slight nausea. No articles overthrown. Pictures on walls awry. The N. E. part of the buildings suffered more than any other part. The writer mentions subterranean sounds (Barisal Guns) like distant artillery heard for long ages in Ludhiana. Such are more frequent in the hot and rainy season. They start in one quarter and continue there till they die away in about an hour. He was never able to locate them and failed to explain them by bombs, etc., exploded at native weddings, etc. No fixed period or times associated with their appearance. A few days before the earthquake at 11 A.M. they were unusually loud. Since the earthquake there has been a lull.

Multan.

Time.

An Assistant Stationmaster of Amritsar, on leave at Multan, noted the time of the shock at once, by a clock keeping correct railway time. The time was 6-12 and the duration a little over 1 minute.

Earthquake Forms—Multan.

Captain G. W. Robinson, 27th Punjabis.—One main shock, very distinctly felt, caused nausea, houses creaked but no plaster fell. It was severe enough to wake most people and make them leave their beds. No difficulty in keeping equilibrium. No sound noticed.

Narain Das, Meteorological Observer, Multan Observatory, and Head Clerk in Civil Surgeon's office.—No preliminary tremors, 3 main shocks at intervals of about 1 second. The 1st and 3rd intense. There were tremors for 1 minute afterwards. Direction S. S. W.—N. N. E. Buildings shook, doors and windows rattled, hanging lamps swung, pictures were displaced. No buildings in Multan were cracked, nothing overturned, etc. No sounds.

Phagwara.

Time, etc.

Time of the first shock, 6-10 A.M.; duration 1½ minutes: direction appeared to be from E. to W.

Earthquake Form—Phagwara.

Heera Lal Varma, Telegraph Master.—Time 6-10, Madras time, by office clock, stopped. During the first violent shock the direction was apparently E.—W. The walls of houses trembled. The floors of all rooms terribly shaken. It was difficult to stand. No objects overturned. Fine cracks in rooms. The sound was like a heavy vehicle on the road near by and just before the main shock.

CHAPTER IV.

REMAINING PARTS OF INDIA NOT VISITED BY THE GEOLOGICAL SURVEY.

For this vast area, which the officers of the Geological Survey were unable to examine, the earthquake forms furnish the only evidence. The particular arrangement of these that has seemed the most suitable is generally one by districts, and the order in which the latter are taken is shown by the following groups, which disregarding the provinces in which they may occur, sweep round the epicentral area from N. W. to S. E. That is to say—each group of districts begins at the N. W. end of the epicentral area, sweeps round in a curve and finishes at the S.E. of the epicentral area. The groups follow each other concentrically, embracing successively areas further and further away from the epicentrum. In the case of areas very far away from that region, from which only a few records have been received, larger group units are however adopted, such as Baluchistan, Central India, Burma, etc. As explained in the Introduction, it has been found impossible to quote all the earthquake form reports. In each district or group unit the localities are arranged alphabetically.

GROUP 1.

Chamba.	Dehra Dun.
Gurdaspur.	Garhwal (Native).
Hoshiarpur.	Garhwal (British).
Simla.	

GROUP 2.

Kashmir (including Jamu).	Amballa.
Sialkot.	Saharanpur.
Amritsar.	Bijnor.
Kapurthala.	Naini Tal.
Jullundur.	Almora.
Ludhiana.	Azamgarh.

Group 3.

Gujrat.
Gujranwala.
Lahore.
Ferozepore.
Faridkot.
Patiala.

Karnal.
Mozaffarnagar.
Meerut.
Moradabad.
Bareilly.
Pilibhit.

Group 4.

Hazara.
Attock.
Rawalpindi.
Jhelum.
Shahpur.
Jhang.
Montgomery.
Hissar.

Jind.
Rohtak.
Delhi.
Bulandshahr.
Budaun.
Shajahanpur.
Kheri.

Group 5.

Chitral.
Peshawar.
Kohat.
Mianwali.
Mooltan.
(returning to the N. W. frontier).
Bannu.
Dera Ismail Khan.
Dera Ghazi Khan.
Lyallpur.
Bikaner.
Jaipur.

Alwar.
Gurgaon.
Bharatpur.
Muttra.
Aligarh.
Agra.
Etah.
Mainpuri.
Farukubad.
Hardoi.
Sitapur.
Bahraich.

GROUP 6.

Jaisalmer.
Marwar or Jodhpur.
Sirohi.
Merwara.
Ajmer.
Kishangarh.
Tonk.
Mewar.
Karauli.
Kotah.
Jhalawar.
Etawah.
Jalaun.
Cawnpore.
Unao.
Lucknow.
Bara Banki.
Gonda.
Hamirpur.
Fatehpur.
Rae Bareilly.
Fyzabad.
Basti.
Banda.
Allahabad.
Partabgarh.
Mirzapur.
Gorakhpur.
Benares.
Ghazipur
Ballia.

GROUP 7.

Afghanistan.
Baluchistan.
Bombay.
Central India.
Central Provinces.
Bengal.
Eastern Bengal and Assam.
Nepal.
Madras.
Burma.

GROUP 1.

Chamba State.

Chamba.—Ram Dass Kakar, Telegraph Master. Time 6-10 by office watch. There were 3 shocks at intervals of a few seconds. Direction E.—W. and N.—S. It was distinctly felt. Two houses (mission house and travellers' bungalow) collapsed. Nearly all houses show cracks, often amounting to rents and fissures. A boulder fell from the slope. Fire tubs in the verandah nearly emptied of water. Hanging pictures moved. No earth fissures. Rumbling sound just before main shock.

Gurdaspur District.

Aliwal.—Mr. F. W. Shonemann, Executive Engineer. There were, first, violent shocks which after 10 seconds became, second, a regular forward and backward motion, apparently horizontal. Total duration 3 minutes by guess. Direction N.—S. by fern basket, cracks in walls, church spire, and bottles on mantelpiece. The church spire was broken and the top stone shifted S. The bottles fell. Tumblers did not fall, but shifted ¼ inch N. Cracks in arches of roof.

Bakloh.—Postmaster. A shock of 2 minutes' duration. Direction E.—W. Most severe.

Batala.—Mr. J. A. Ward, M.A. Arches and walls running N.—S. are cracked, those E.—W. not so.

Bhimpur (*Bari Doab Canal*).—Mr. F. E. Kanthack (see p. 344).

Dalhousie.—Mr. H. Foster, Military Telegraphist. Time 6-15 A.M. by clock regulated by telegraph clock. There were, first, innumerable trem. vibrations, second, the main shock. Direction N.—S. Office walls slightly cracked. Fissure in earth, slight, near barracks. A loud rumbling sound during main shock.

Dhariwal.—Postmaster. Duration 2 to 3 minutes. Direction W.—E and N.—S. Sound like cannons. He thought walls would fall. Telegraph poles trembled very much. He was not in sound senses to make observations. [Although not mentioned by the writer, the high chimneys belonging to the Dhariwal Mills were apparently not damaged, as they were standing when the author passed through on his way to Pathankot.]

Gurdaspur.—Chiman Lall, Postmaster. There were 2 main shocks N. E.—S. W. the shocks were awful. Trees had a tremendous motion, they seemed to kiss the ground both ways. Doors opened and closed with great noise and force. The buildings were one-storied, and with solid foundations. Therefore no loss of life. Cracks nevertheless in every building, and sometimes dangerous. Nothing overturned. The effect on tanks was described as the same as that of the moon on the ocean. The waves travelled in both directions, first opposite and then with the earthquake wave. Hanging lamps moved

N. E.—S. W. No sound before the shocks. With the shocks came a noise very irregular and having certain beats which varied with the intensity of the shocks.

Pathankot.—(See p. 8.)

Hoshiarpur District.

Hoshiarpur.—Dr. D. N. P. Datta, Civil Surgeon. Trem. vibrations not noticed. Principal shock very severe. Horses began jumping about, bungalow began to shake and he ran out but could not stand. After a while everything was shaken irregularly and violently. Bungalow rocked to and fro. Trees bent up and down. The ground appeared like a sheet of water in a storm (like a rough sea). He heard no sound. Chimney stack fell W. and E., walls of old house cracked from above downwards. [The writer also gives details of a tour *viâ* Jawalamukhi, Daulatpur, Nagrota, Palampur, etc., which area is, however, covered by my own notes, see pp. 38—44.]

Hoshiarpur.—Bishan Das, Head Treasury Clerk. He was in the open air walking and so did not feel the prelim. tremors. The main shock was severe, duration about 3 minutes. First, trees rocked and swayed as if a hurricane was blowing. As the shock became more severe he had to kneel, and finally sit on the ground, as also had the coolies working near. Bricks, etc., fell from houses on the W. side. Slight cracks in uppermost stories of houses and arches. A few fissures, E.—W. in the ground $\frac{1}{8}$ inch wide. "Kacha" houses stood the shock very well. No sounds noticed.

Simla District.

Dagshai.—Postmaster. Time 6-10. Duration 3 minutes. Many houses cracked.

Dagshai.—Sita Ram, Signaller. Time 6-15 A.M. by a good time-keeping watch. Direction E.—W. Very heavily felt, and all things were in a moving condition. Many houses cracked, some chimneys fell. Sound like "heavily blowing."

Mashobra.—Time from 6-0 to 6-25. The house trembled.

Rohru viâ Mashobra.—Mr. C. E. Tendall. Time about 6 A.M. Direction N. W.—S. E. There was one severe shock. In his own house nothing was thrown down and no stones displaced. No damage. Water in tub agitated violently and water thrown W. S. W. No damage in Pabar valley beyond some few houses being cracked Those on ridges chiefly affected. Some few very old rickety houses in the valley have fallen. The high ridge dividing the Pabar and Sutlej rivers seems to have been the limit of the severity of the earthquake. On the Sutlej watershed the village of Rampur suffered severely. Many villages in the Nogli river basin also. The road from Rampur to Sungri *viâ* Bali also suffered in some places. Serahan, 2 stages from Rampur up the Sutlej valley, had no damage.

Sanawar.—Mr. W. J. Warburton, Telegraph Master. Time of 1st shock 6 A.M. 2nd shock 6-15 A.M. by watch checked by telegraph time. Direction W.—E. by motion of church steeple which was inclined 60° out of the vertical. There were no trem. vibrations before or after the main shocks.

Chor Peak near Simla.—The Meteorological Observer, Sarain Observatory. Time 6 A.M. It was a violent shock and damaged many temples, devtas and old houses. In one village near Sarain 2 women and 6 cows were buried.

Bhajji State.—Maj. M. W. Douglas, C.I.E., Superintendent, Hill States, reports that the Rana of Bhajji heard loud noises resembling the firing of cannons on 5th and 7th April.

Solon near Simla.—The Postmaster. Time 6-5 A.M. by the telegraph clock. There were several shocks lasting about 15 minutes. The P. O. building cracked in five places.

Simla.—(See p. 73.)

Dehra Dun District.

Barkot.—Pitambas, Forest Ranger. There were 1st trem. vibrations. He sat up and then ran out. The thatched *chappar* and post fell and moved S. W.—N. E. Doors rumbled and other building timbers. The shock was felt with such an intensity as if some one were shaking the bed Cracks in walls running W.—E. and also in arches of doors.

Chakrata.—Mr. H. James, Mily. Telegraphist and Meteorological Observer. Severe shock lasting 2 minutes and several more minor shocks afterwards. Direction N.—S. No sound. Bungalow swayed N.—S. No damage to office building, but great damage to houses in the bazar.

Dehra Dun, Mussoorie, Landour, Rurki, Saharanpur and Hardwar. —(See p. 80.)

Karanpur.—Four or five distinct shocks N. W.—S. E. by fall of bottles, etc. Sound indeterminate. Eucalyptus tree in compound moved N.—S., its range of swing being 4 or 5 feet, the tree being about 30 ft. high. Some previously dry streams and wells have become supplied with water.

Raiwala.—Mr. C. Hope, I.C.S., Superintendent of the Dun. There was one big shock with 3 small vibrations within 5 minutes of the big shock. He was in a small two-poled tent, and was awakened by a tugging at the tent ropes as if some animal had run against them, and by a violent flapping of the curtains at each end as if a gale of wind had sprung up.

Rambagh.—Mr. J. C. Tulloch, Deputy Conservator of Forests. First feeling as if a dog under the bed scratching himself. A double-storied cottage 40 feet high swayed about 2 feet on either side of the vertical. Direction N. W.—S. E. Sound as if a train passing in a tunnel.

Garhwal District.

Lansdowne.—Capt. H. M. MacTier, 1-39th Garhwal Rifles. Time 6-13 by watch set by time gun. The shock was severe. Direction N.—S. Objects thrown down were a looking glass from a chest of drawers, 2 pairs of leather gaiters. A riding boot with tree was flung to the S.

Pauri.—Mr. J. H. Messmore, Superintendent, Garhwal Mission. Fifteen piles of rupees (20 in each) were thrown down N. They were free to fall N. or S. or E. but not W. They were in an iron safe built in the wall running E.—W. The movement seemed twisting. Other writers, Mr. E. M. Rennell, P. W. D., and the Postmaster, mention that the shock

was most violent. Water spilt out of basin N. W.—S. E., a chimney stack fell N. No bottles, etc., overturned. All cracks were vertical. A chestnut tree moved N. W.—S. E. Roof cracked and rattled its slates. No sound.

Srinagar.—Pandit Gobind Prasad Ghildyal, B.A., Excise Inspector. Principal shock lasted 5 minutes about. Trem. vibrations for a few secs. Before the shock it appeared as if some big rat ran over planks followed by a cat from W. to E. Trees shook N.—S. People were terrified. Buildings cracked chiefly in W. and N. walls. All door arches cracked.

Srinagar.—Postmaster. He reports that many houses were cracked and the flow of the Ganges stopped during the earthquake.

Tehri Garhwal District.

Mantar.—Kaushi Ram Kapur, Deota Range Officer. Two principal shocks, the interval being less than ½ hour. The first was the more severe. Direction E.—W. by the swinging of Chir pine trees and oscillations of walls. The oldest inhabitants say they have never felt such a severe shock. Large stones overturned [presumably on slopes].

Tehri.—Suraj Bali Dikshet, Postmaster. Duration of the shock about 4 minutes. Direction N. W.—S. E. by cracks of walls. H. H. Maharaja's elephant tried to break loose. Four arches of the Maharaja's Castle badly damaged and thrown aside. It is built at a high level. Clock tower cracked in upper part.

GROUP 2.

Kashmir.

Owing to Kashmir being one of the areas of the Himalaya and of India generally where earthquakes are common and have been destructive within modern times, there was much anxiety during the first few days after the earthquake regarding the fate of that country. Events, however, showed that the shock, although very severe, was not very destructive.

In this state the towns are arranged in alphabetical order without being grouped under their respective districts.

Baramulla Pattan.—Sant Ram, Settlement Tehsildar. He was indoors lying down, but went into open air at first shock. Three distinct and principal shocks lasting for 3 or 4 minutes. Direction E.—W Kacha walls of house fell to W. and heavy stone of Pandulari temple was projected 2 to 3 yards to the W. No sound.

Bhadaywar viâ Jummoo.—Mr. G. F. Moyer. Time sunrise (sun just coming over the hills). Direction of shock E.—W. After the first shock there were several lighter ones continuing for about 1 hour afterwards. The main shock was a severe one, but there was no damage.

Chilas.—Thakarwaso, Telegraph Master. Time about 6 A.M. He was sleeping. One slight shock.

Dras.—Hari Râm Sethi, Meteorological Observer. Time 5-50 by telegraph time, watch correct with Madras time. Three severe shocks during the first minute. Some other shocks during the ensuing 35 minutes. Roof and doors and windows severely cracked [later he says no damage or cracks on houses, but cracks on ground ice]. Maximum thermometer fell in cage but was undamaged. At Machori and Baltel passes much snow fell in avalanches. No sound.

Astor-Gilgit road.—Mr. H. Dean, Telegraph Department. Time 6-30 by telegraph clock. He was indoors lying down. Several shocks felt E.—W. Rattling of doors before main shock. Duration about 3 minutes. Bed rocked to and fro for 3 minutes.

Astor.—Dhanpatkai, Tehsildar. One continuous slight trem. vibration lasting ½ minute. Direction S. E.—N. W. No sounds.

Bandipur.—Mr. F. Donne, Telegraph Master. Direction E.—W. by swinging of a notice board in the verandah. Duration about 5 minutes. Office buildings, trees and other objects were rocking visibly. No separate shocks but of one continuous intensity from beginning to end.

Gharhi (Mozaffarabad Dist.).—Raja Ram, Branch Postmaster. Three shocks, each after an interval of a little over 1 minute. He was shaken in bed as if some one was waking him. Tables trembled. No sound, no damage.

Gilgit.—Agency Surgeon. One shock, no trem. vibrations. Distinctly felt. No damage.

Gupis.—One shock distinctly felt. There was also the noise of big stones falling from hills surrounding the station. No damage, no anxiety.

Gupka (3 miles E. of Srinagar).—Mr. M. Peychand, Director of Agriculture, Kashmir State. Indoors first, afterwards jumped out of doors. Three distinct shocks without stoppage of vibration. Interval between first and second = 30 seconds. Interval between second and third = 1 minute. The second shock was stronger than the first, and the third was similar. Duration of shocks 3 minutes in all. Direction S. E.—N. W. judging by movement of corners of walls rocking 2½ inches. No noise, but others heard report as of a big gun after the first shock travelling N. W.—S. E. In his opinion it was the biggest shock since 1885 (there have been 8 to 10 shocks a year during this interval). Plaster fell from upper story of house and earth from mud roof. Three unimportant cracks in walls running S. W.—N. E. The rocking was about twice every second. Whereas the 1885 earthquake brought down plaster of all the rooms and put the outer walls out of plumb as much as 3 inches, this time only a few pieces of plaster fell and the walls do not appear to have bulged.

Gurais.—Mr. L. H. Coombs, Telegraph Master. One shock. Duration 2 minutes. Direction W.—E. by shaking bed. Severe and distinctly felt. No damage.

Handwara.—Mirza Jalal Uddin, Tehsildar. One severe shock. Duration about 4 minutes. Then interval of 2 minutes. Then second shock severe and of 4 minutes' duration. The shock so severely felt that a man could remain standing only with difficulty.

Islamabad.—Mr. A. L. Coverdale, C. M. S. Hospital. Time 6-17 A.M. at close of first severe shock by clock set with midday gun in Srinagar. Two bicycles set in rests fell S. The house rocked violently. Trees swayed to and fro. Walking was like on deck of a ship. Chimneys were overturned. One fell N. W.

Jammu.—(See p. 171.)

Sonemarg.—Three shocks at intervals of ½ second. Trem. vibrations for 5 minutes afterwards.

Kolakam.—Sohun Sing, Tehsildar. Three distinct shocks, first slight, second and third severe. Direction E.—W. by cloth hanging on string. According to report water undulated on canals.

Leh (Ladak).—Rev. H. B. Mark, Moravian Missionary. One shock of duration 1 minute 10 seconds. Direction N.—S. Distinctly felt. One door banged, window panes and iron stove rattled. Curtains waved. Second shock about 10 minutes afterwards. It was hardly felt but the curtains waved again. It lasted several minutes. He felt sea-sick.

Bunji.—Haridutt Tiwari, Telegraph Master. One shock slight with no vibrations, of very low intensity. Distinctly felt. No sound.

Minimarg.—Mr. C. Kilmar, Telegraph Master. One continuous shock lasting 1½ minutes. Direction W.—E. Rumbling noise during the shock. No damage.

Monza-Boodhgam.—Felt shock W.—E. Heard noise for a short time. Two trees shook W.—E.

Muzafferabad.—Hasmat Ullah Khan, Tehsildar. Two shocks distinctly felt.

Fyemo (15 miles W. of Leh).—Dr. E. Shawe. He was indoors in the second story of the rest-house moving about at the time. There was a shaking motion for 1 minute. He thought it was someone on the roof. Direction N.—S. by hanging articles. He went out to see who was walking on the roof, and then recognised that it was an earthquake. His wife was made quite sick. Coolies were made dizzy. It was not alarming, no damage. A few rocks and boulders fell from the hill sides.

Uri fort.—Azizdin Ashac, Tehsildar. First a rumbling noise and tremor, second severe shocks N. and W. (*sic*) without intervals. The station was rocking to and fro. Débris fell down from here and there. No damage, no loss of life. Clothes hanging from pegs moved.

Poonch.—Pandit Bhairati Dutt Joshi, Head Master, Victoria Jubilee School. Time 6-20 A.M., telegraph time (Madras). He was indoors lying down at first. There was first a rumbling noise like a heavy cart on metalled road. Next 2 prominent shocks, very severe, with an interval of

nearly 10 seconds. Trem. vibrations lasted for 2 minutes. Direction N. E.—S. W. The rumbling noise continued till after the second shock and then faded away. No serious damage or loss of life. Two or 3 old houses fell down. Rows of birch trees swung E.—W. for several minutes after the shock subsided. Dust haze, yellow and very heavy, preceded the shock by a few days.

Rajauri (*Riasi District, Jammu Province*).—Mr. W. S. Talbot, I.C.S., Settlement Commissioner. He was in a tent in bed. No trem. vibrations noticed. Main shock rather of the nature of an almost continuous oscillation. Duration about 1 minute. Very distinctly felt. Observer was awakened by the rocking of the bed, but did not get up. Direction E.—W. rather than N.—S. No particular damage noticed. No sound. He also visited the following places :—Darhal, Budil, Poni, Riasi, Udhampur, Chineni, Ramban, Banihal, Vernay and Islamnagar. He noticed very little damage, a small pakka fort collapsed at Riasi and some ordinary native houses at Udhampur.

Sangri (*Aus R.*), *lat. 33° 22′, long. 74° 50′*—Mr. C. M. P. Wright, Kashmir Mineral Co. His camp was on the river gravel just at the junction of the Murree rocks and the Kuling and Supra-Kuling series. The shock was felt slightly.

Segpoora (*Ootur. Machipooi Dist.*).—Lieutenant-Colonel S. D. Turnbull, retired list. He was lying down in bed on the ground floor of a Kashmir 3-storied "lurry." Two shocks were most distinctly felt with constant trem. vibrations between, and possibly before, the main shock. Duration 2 or 3 minutes. Direction E.—W. by movements of bed, and N.—S. by rope with clothes. He was on the point of leaving the house "lurry" but did not do so as it was a new one and likely to stand.

Skardu (*Ladak Dist.*).—Gandamall, Meteorological Observer. He was indoors lying down at first but got up immediately to watch the occurrence. Three terrible shocks of equal intensity followed by trem. vibrations. Intervals of 4 or 5 seconds. Direction N.—S. by water. No sounds. Timbers of roof were crashing very frightfully and branches of trees moving up and down.

Sonemarg.—Meteorological Observer. (By telegram) 6-0 A.M., slight, lasted 1 minute 30 seconds.

Sopor.—Sub-Postmaster. No movement of any kind seen. It was hardly felt. Hanging lamp fell and broke. No sound.

Srinagar (*Munshi Bagh*).—Dr. E. F. Neve, F.R.C.S. Time 6-10 A.M. by watch regulated at midday by gun. There were 2 severe shocks and trem. vibrations afterwards for an hour. Direction E.—W. Pictures on walls facing N. swung to the W. and remained there. House oscillated several inches. All chimneys cracked or bent. Much plaster fell from E. facing wall. One book fell out of book-case facing E. This house was on alluvium of the thickness of about 200 feet at greatest. The Mission Hospital on a rocky hill was uninjured.

Srinagar.—Mr. C. J. Burrow, State Bandmaster. He has had 20 years' experience of Kashmir. He was indoors at first, afterwards out of doors with family. He first felt a sidelong to and fro movement. There were no shocks, but violent tremors which lasted 3 minutes or more. Direction W.S.W.—E.N.E. The house in which he was was built of a wooden frame and brickwork. As judged by hanging lamp, there were tremors during best part of the day lasting up to 3 P.M. No sound. He considers this unusual, as in 40 or 50 shocks felt by him during 20 years there was always a sound like distant thunder before the shock or tremor. Outside the chenar and poplar trees swayed 3 feet, *i.e.* 1½ feet each way from the vertical, first W.—E. and then N.W.—S.E. Such a tremor has never been experienced by him before. The first one was so bad that he could hardly stand.

Srinagar.—Mr. B. Thornhill, Chief Engineer, Kashmir Railway Survey. In a house-boat lying in bed. One continuous shock. A wave or swirl of water came down the river showing a return shock which must have been very slight. Direction W.—E. No sound. No objects in boat overturned. Cracks in old office on land, and one partition wall cracked and bulged 6 inches. Servants say that a small wave travelled W.—E. against the stream and returned after 2 or 3 minutes.

Srinagar.—Dr. A. Mitra, Meteorol. Reporter to the State. (With reference to his remarks and the seismogram recorded by the Milne-Casella seismograph (see p. 352).

Srinagar.—Mr. W. Rehill, Postmaster. Time 6-10 A.M. by watch and telegraph clock regulated every day by gunfire by Madras time. Among other things this observer noticed a rumbling noise a few seconds before the shock like distant thunder. House seemed to move 3 inches. Bottles were overturned in cupboards generally towards W. Hanging lamps swung about 2 feet E.—W.

Titwal Station (Tehsil Kernah).—Bala Koul Moharir, Grazing Department. Two principal and prominent shocks with 15 seconds interval. The first was slightly the more intense. Trem. vibration lasted for 2 minutes. Direction E.—W. by falling to W.

Sialkote District.

Nowshera.—Mr. W. J. Rose, Government Telegraph Office. Prelim. tremors felt; every door rattled. The main shock was a fearful to and fro movement. He felt giddy. Trem. vibrations after for several seconds. Direction E.—W. It was very severe, far more so than he felt at Patna during the 1897 earthquake. Large trees moved. Punkah swung violently. No damage. No sound.

Sambrial.—Charu Duss, Sub-Postmaster. Two large and many small shocks. Direction N.—S. Cracks in wall. No sound.

Sambrial.—Captain Deas, I.M.S., 51st Sikhs. There was movement first from side to side (E.—W.) and then up and down. Distinctly felt. Punkah ropes swung for several minutes (there was no punkah attached). Trees moved. Birds left trees. Nausea. A rumbling noise before first shock about 30 seconds.

Sialkote.—(See p. 168.)

Amritsar District.

Raya.—Ali Mahomed, Sub-Engineer, Bari Doab Canal. Time 6.15 A.M. by clock checked a week ago. Direction E.—W., about,

Doors and windows shook heavily. Water from canal spread over canal bank.

(See also p. 344.)

Kapurthala State.

Kapurthala.—Pandit Birbal, Magistrate's Office. Time 6-9 by Bee clock regulated by State clock keeping Madras time. First, no trem. vibrations, second, three distinct shocks, the first being very intense and lasting 50 seconds. Then 1 minute interval followed by the second shock which was terribly intense and made all the buildings move to and fro. Next after 1 second interval, third shock lasting 55 seconds. Finally trem. vibrations for 2 minutes 56 seconds. No loss of life. The State houses suffered much. They were cracked more or less. One-storied houses with mud walls stood the shock wonderfully well. There was a thundering noise 1 second before first shock like a running mail train.

Jullundur District.

Jullundur.—(See p. 146.)

Kartarpur.—Jamma Dass Sahgal, Sub-Postmaster and Telegraph Officer. At 6 11 clock stopped. There were about 5 movements in direction N.—S. Nearly all houses in the town damaged more or less. High buildings suffered most. The historical monument to the Sikhs fell down. Clock moved to S. about ½ inch. No sound.

Nakadar.—Hir Dey Ram, Sub-Postmaster. The first shock was terrible.

Nawashahr.—Signaller. Time 6-10. Distinctly felt. Postmaster left his house.

Phillaur.—Mr. T. E. Collins, Loco. Foreman, N. W. Railway. Time 6-10 by watch correct with N.-W. Railway platform clocks. Platform clock stopped at 6-10, presumably by the earthquake. One very severe shock from 6-10 to 6-14. Direction S.W.—N.E. He was able to stand without support which he was not able to do at Bongong in Jessore in the 1897 earthquake. [This comparison is no doubt quite correct. Jessore lies N. E. of Calcutta and in the 1897 quake must

have been much more violently affected than Phillaur in that of 1905.] Nothing was overturned. All door and window arches facing N. and S. were cracked. Roof girders of station house and loco. shed displaced E. and W. along their length. Archways subsided 1 inch. Water in Sutlej River close by vibrated and spread into dry hollows in the bed of the river. No sounds.

Rahon.—Shib Dial, Sub-Postmaster. One severe and tremendous shock, very intense. Direction E.—W. Buildings trembled, and many were cracked, but none fell. There was a roaring sound like a thunder-storm 1 to 2 seconds before the main shock.

Ludhiana District.

Ludhiana.—(See p. 173.)

Jagraon.—Alla Baksh. Time 6-15 by office clock corrected every day at 4 P.M. with Madras time. One main shock. Walls of many buildings cracked. Direction W.—E. by movements of office almirah. Sound like mail train passing at full speed.

Khanna.—Lakshami Chand, Sub-Postmaster. Cracks in walls of Post Office and other houses in the city. Books and forms of records overthrown S.—N. (the slope of the shelf was towards N.). No sound.

Amballa District.

Amballa.—Captain A. A. Crookshank, R.E. The earthquake was distinctly felt. Brushes were knocked off the dressing table. A door closed by an English spring lock was burst open. In a nullah subsoil water was forced 5 feet and left little cones of sand 1 to ½ feet high. Bed of nullah previously dry for 3 weeks was now covered by pools. It looked as if a flood had recently come down. Fissures in the grand trunk road parallel to the bed of the nullah. Buildings with archwork or with old work joined to new (being the most inelastic form of structure) suffered most. No sound.

Amballa.—Mr. H. E. Chappel, Superintendent, Telegraphs, Delhi Division. Pendulum clock stopped at 6-12. The door of his room shook. He left the house quickly. There was a shower of bricks

from the chimneys. Trees swayed as on ship-board. First shock 2 to 3 minutes. Hanging lamp swayed N.—S. Cracks in house corners. Chimneys destroyed. Burnt brick buildings belonging to the Military Department quite destroyed. Telegraph running nearly E.—W. got loose having pulled the stay out and the post having gone over to E.

Amballa.—Mr. W. H. Johnson, Telegraph Master. Time 6-13 by office clock stopped between 6-13 and 6-14. The first shock, followed by trem. vibrations, lasted 70 seconds. Direction S. W. His body swayed freely in bed 2 inches. Outside he had to stand still to maintain his balance. Flower vases 8 inches by 2 inches were upset on mantel-shelf in south direction. Training class buildings damaged. No sound before. During the vibrations a dull rumbling sound followed the first shock by 8 seconds. This was followed by distant booming as of guns.

Amballa Cantonment.—Mr. C. E. Goument, Sanitary Engineer to the Government. Preliminary tremors were noticed. The main shock lasted about 3 or 4 minutes. No definite shooks, simply swinging movement to and fro. Direction N.W.—S.E. Large bucket oscillated freely. Large pipal tree moved backward and forward as in a high wind. He made no detailed examination of the damage. Sound a rumbling accompanied by sounds resembling those produced by collapse of tiled roof buildings.

Amballa Cantonment.—Mr. H. C. Robertson, Executive Engineer. Vibrations all through. No distinct shocks and no distinct to-and-fro motion such as would convey any sense of direction. Nausea produced. Walls in almost all houses cracked, in many cases from top to bottom. A chimney at the pumping station of Amballa City was cracked with fine hair-crack right round it in a horizontal plane. There was no displacement. The chimney is 7 feet across, 35 feet high. The crack is 23 feet 10 inches from the summit, and the portion above the crack weighs 24 tons. At the Circuit House (newly built) there is a continuous crack right round all four sides at junction of the roof. No sound.

Amballa City.—Jagun Nath, Sub-Postmaster. Direction E.—W. Nearly all big houses of the city cracked and some fell. No sound.

Amballa City.—B. Sant Ram, Head Signaller. Many upper stories of buildings fell. Sound like a river flowing or train moving. Motion of all articles in post office.

Amballa City.—R. S. Shankara, Meteorological Observer. Direction N.W.—S.E. Duration 2 minutes. Very severe, more so than previously experienced. Nearly all houses damaged. Many fell. Many persons injured and 2 killed. People terrified and slept in the open air.

Amballa City.—Abdul Rahman, Sub-Postmaster, Sudder Bazar. Direction W.—E. Distinctly felt. Roofs and walls swung like a boat in water. No particular sound.

Dadupur.—Mr. J. B. G. Smith, Officiating Executive Engineer, W. Jumna Canal. Two principal shocks with 2 minutes' interval. Direction S.W.—N.E. Most distinctly felt. He ran out and could scarcely keep his feet. Two noticeable cracks, vertical in corners. Water in bath tub severely shaken. Milk in cream dishes thrown out. The dishes were 2½ inches high and the milk was 1½ inches deep.

Dadupur.—Sohan Lal, Sub-Overseer, W. Jumna Canal. It was severe and continued 3 minutes. The canal water waved. Small boats were thrown out of the water by the serious beat of the first shocks. Small cracks in buildings. Lamps, etc., shook. Dry channel of river burst and water and sand gushed out. The sound was "felt" under ground like a heavy railway train from W.—E. It occurred about 2 minutes before the first shock.

Jagadhri.—Haji Mahomed, Sub-Postmaster. Time 6-17 by Post Office clock, Madras time. Tremors were felt. The main shock was a "stirring up and spinning" of the houses. Direction W.—E. first, and afterwards N.—S. It was a very terrible shock. He thought the end of the world was coming. Trees and houses and all solid things moved violently in a windless atmosphere. Many people slept out 8 or 4 days. A water pitcher overturned. Cracks in buildings N.—S. and E.—W. Water flew out "eastwards from north

to south." Up and down movement of houses. Sound a rumbling and roaring preceding by 5 seconds the first shock.

Jagadhri.—Sham Lal, W. Jumna Canal. Doors shook. Walls cracked in several places. Some buildings feil down. 'Arches of door cracked at crown. No sound.

Deodhur.—Mr. P. Parker, A.M.I.C.E., B.C.E. Time, began 6-10′-40″ and lasted till 6-12′-43″ as recorded by watch compared with Jagadhri railway time. (The observer records a possible error of 10 seconds, but the accuracy of the time at Jagadhri is doubted.) There were 2 shocks, the second the more violent. Direction W.—E. by guess. The shaking was constant in intensity for 40 seconds. His bed shook and woke him. Three mud walls 10 feet high by 1 foot thick fell down. An empty soda water bottle was not overturned. At Jagadhri 3 houses fell and one man was killed. The N.-W. Railway across the Western Jumna Canal had its brickwork cracked, whilst the woodwork by pressure chipped off flakes from bricks of pier. No sound: the writer is certain of this as he knows the earthquake sound quite well, and he was in a tent.

Katka.—Gurdit Singh. Time 6-12 A.M. by office time piece. Three distinct shocks and two afterwards. The first was very severe and the second and third slight. Direction E.—W. by hanging lamp. Office walls in great motion.

Kasauli.—Mr. E. J. Mullins, Telegraph Master. Three shocks in quick succession, the first the most severe, like a cart on a rough road. Office doors slammed, bed shook irregularly, his head reeled. It was alarming. The second shock produced similar but less marked results. The third was a very distinct tremor gradually dying away. One pinnacle of the church was thrown to the ground, and the other three so damaged that they had to be taken down. The station hospital was also damaged, particulars unknown. No sound.

Nahan.—B. Badri Naik, Sub-Postmaster. Time 6-5 A.M. by clock tower, the clock daily compared with Madras time. Two principal shocks. Direction N.—S. by falling houses. Some shops 9 to 10

feet high fell during the second shock. Some fell to the N., others to the S. Nearly all houses cracked.

Rupar.—Postmaster. Duration 7 minutes. Direction N.—S. Sound a thundering noise accompanying the first shock.

Tajawala.—Mr. W. R. Turner, Assistant Engineer, Karnal Division. One continuous shock increasing in violence until it attained its maximum force and then ceased. Direction varying between W.—E. and S.W.—N.E. It was distinctly felt, a kind of racking and twisting movement. No objects overturned. A sun-dried brick house cracked in 4 corners. Old rest-house of the same pattern severely cracked, all the cracks being approximately vertical. Sound like a heavy running vehicle during the shock.

Saharanpur District.

Deoband.—Damodar Dass, Sub-Postmaster. There was, first, a blowing of wind and rustling of leaves, followed by 5 seconds interval; second, one principal and prominent shock; third, 6 trem. vibrations. Direction N.—S. The shock was very intensely felt. He felt as if some one was violently shaking his body. Doors trembled; books and inkpots upset on the table. Windows fluttered about very quickly and noisily. The whole house shook as if about to fall. Giddiness was produced. There were earth-fissures, and some of the houses of the town have fallen down.

Jawalapur.—Postmaster. A distinct shock. Several walls cracked.

Manglaur.—M. Abdulmahid, Government Pensioner. Time 6-15 by watch regulated by railway time. There was, first, a slight shock which increased in a fearful manner in a few seconds. Duration $1\frac{1}{2}$ minutes or less. Direction W.—E. by articles fallen from the corner. Sound like a gale of wind. He experienced great difficulty in walking. At first charpoys and hanging things moved, afterwards doors, walls, roofs and everything began to swing to and fro, and closed doors were burst open. Animals cried with fear. Hens crowed, birds screamed. A woman and child were killed under a wall. Walls of enormous size were overturned, mostly N.N.W. to E. (*sic*). .Cracks

in 40 buildings, mostly in walls facing N.W., N.N.W. and E. Water of tank rose very high, N.N.W.—E. (*sic*). A parrot in a swinging cage whistled as it had been taught to do when danger was near.

Pathri (10 miles south of Hardwar).—Mrs. E. Rushton. Three distinct shocks, the first being very strong. No sounds. She was awakened out of a sound sleep. Hardly able to stand or walk. A soda water bottle fell off a shelf. The canal was in waves, trees shaking wildly and swaying through arcs of 15° on each side of the vertical. Mr. W. H. Rushton, Executive Engineer, N. D. G. Canal, gives the direction as N. 15° E. The canal wet its banks. (See also Mr. Simpson's account, p. 118.)

Ranipur (3 miles south of Hardwar).—Sansar Singh, Forest Ranger. One main shock. The whole house and ground trembled. Direction W.—E. by pictures on the wall. One picture fell No other damage. (See also p. 118.)

Saharanpur.—(See p. 126.)

Bijnor District.

Bijnor.—Babu Dharani Dhar Dass, Supervisor, District Surveys. Four shocks in all, the first being the most intense. (The rest of the four shocks are given at later hours by the writer showing that they are really aftershocks.) The shock produced giddiness and nausea. Buildings vibrated, doors and windows struck violently against the walls. Alarm among many people who thought they would be buried alive under the houses. Many houses damaged, *e.g.*, the Collector's. a double-storied house which had the walls out of the vertical and several gaping cracks. It was declared unsafe by the Divisional Engineer and was pulled down. Other houses were more or less damaged, but not seriously. Water spilled over E. side of trough, buckets and tubs.

Bijnor.—Kazi Ziauddin, Postmaster. Indoors sitting at first, afterwards outside. Three shocks, the first lasting 2 minutes and being very severe. Direction S.W.—N.E. by fall of articles. No sound except deep vibrations like thunder during the shocks. The main shock

cracked many buildings. Pictures on walls, clothes, umbrellas, etc., on pegs fell down towards N. side. Water in tanks had a N. movement. Earth-fissures near the banks of the Ganges 4 to 5 miles from Bijnor.

Bijnor.—Rev. J. H. Gill, Missionary. The shocks lasted about 1 minute. Cracks in house and chapel. The fallen plaster of both weighed 30 lbs.

Nagina.—The Meteorological Signaller mentions 2 foreshocks, one at 11 P.M. on the preceding day and the second at 2 A.M. on the day of the earthquake (See also p. 355.)

Najibabad.—Thurmilal, Sub-Postmaster. During the first shock the wall of houses first bent from S.—N. and then from E.—W., after which the earth remained in a trembling condition for a short time. Nearly all walls cracked.

Naini Tal District.

Bhim Tal.—Postmaster. Three shocks, the first being the most severe. No buildings destroyed.

Bazpur (18 miles from the hills).—Mr. F. Clayton, Executive Engineer. Duration of shock 1 minute or more. A rumbling stated to have been heard at Haldwani 6 seconds before the main shock. The earthquake was very distinctly felt. He went out of his house to see if the chimneys were cracking. Iron roof and beams cracked, chimneys and trees swayed. He experienced nausea. No objects overturned. At Gadeyur E.—W. end walls parted from main walls, especially at E. ends.

Haldwani.—Telegraph Signaller. Two shocks only felt with 16 seconds interval. Direction W.—E. The sound was a strong bustling.

Jeolikote.—Amlia Datt Jah, Sub-Postmaster and Signaller. Two shocks with 15 seconds interval. Direction W.—E. A humming sound at first. No damage.

Kathgodam.—The Sub-Postmaster. Doors opened and closed again.

Mukhtesar.—Mahommad Akbar Khan, Sub-Postmaster The shock was severe and terrible. Government buildings cracked vertically. None fell down, no loss of life. No sound.

Naini Tal.—Mr. J. Smith, Accountant, Public Works Department. At "Springdale," at the foot of Ayarpatha Hill. Clock stopped at 6-15. Beds shook, closed doors rattled, pictures on walls moved like pendulums, timbers of roof creaked. There was a rumbling noise of falling stones, and small stones fell from Ayarpatha. Duration 2 minutes. A rumbling noise after the shock.

Naini Tal.—Mr. G. Jasbo, Extra-Assistant Superintendent, Survey of India (retired). At the "Retreat." The first shock threw him and his wife each to the E. Duration 10 seconds. There was then a rumbling noise like a distant train which continued about 20 seconds. This was followed by the second shock. Plaster cracked in places. Hanging lamp with 9 ft. swing moved W.—E. The house lies with its long axis E.—W. on a hill spur running N.—S., the hill being to the S.

Naini Tal.—Mr. F. T. Coode, District Engineer, at "The Club." The main shock continued nearly 1 minute, its vibrations being fairly constant throughout. Direction W.—E., deduced from fissures in buildings. No sound heard. The shock woke all in bed. No articles of furniture overturned. Roofs creaked, doors rattled. The general direction of cracks in houses were N.—S. None were badly cracked. The end walls of Ramgarh travellers' bungalow bulged. The only buildings affected were those on insecure soil, and old, previously shaken buildings. Observation pillars for registering any movements of the Ayarpatha slopes did not show any movement

Naini Tal.—Sub-Conductor W. H. Tivey, Supervisor, Public Works Department. One main shock only. Direction N.E.—S.W. Doors and windows rattled. The shock began quietly, and gradually increased in intensity until the bed rocked from side to side. Total duration about 2 minutes. It suddenly ceased. Government House has fine hair-cracks in most of the arches in upper storey walls running N.E.—S.W. (Some are old cracks showing again.) They are of no importance. The cords and pulleys of "Sandow Exerciser" were moving.

Almora District.

Almora.—Mr. C. H. West, Executive Engineer, P. W. D. He first felt as if there were a large dog under the bed scratching himself. This lasted for 10 seconds. Next came the principal shock with a duration of 2 minutes. Direction N.N.W.—S.S.E. No sounds. It was distinctly felt and caused most people to rush out of their houses at once. Only a few remained. The shock was much more severely felt on the crest of ridges, and houses placed there were more severely cracked. Very few objects were overturned. Pictures on walls in houses on the ridge crests were displaced. Old cracks of the earthquake of May 1903 were reopened in many houses. Many are at the junction of cross walls running N.—S. and E.—W. They appear at a height of 7 feet from the ground and extend upwards. Arches are cracked. But damage to house property, as a rule, was not serious. [NOTE.—The earthquake of May 1903 referred to is said by the writer to have had its origin somewhere near Nanda Devi and the Pindari Glacier where he was in camp.]

Kousanie.—Mr. N. F. T. Troup, Hony. Magistrate. He was indoors at first and afterwards in the verandah. First the usual vibrations and then three distinct violent shocks. Water in bath swayed S.W.—N.E. Hanging lamp swayed for 15 minutes. Rushing sound heard before first tremors like a high wind in the trees. No damage.

Ranikhet.—Rev. B. Kitchin, Chaplain. Four shocks between 6 and 7 A.M. preceded by vibrations which passed into rocking movements. Direction E.—W. by hanging lamp. No damage to the station, not even cracks. Boulder fell near Bhowali killing one of the men of the East Surrey Regiment. Other observers mention rumbling noises during the shock, bungalows in a continuous tremble, pictures moved on the walls and in some cases undoubtedly cracks in walls though not of a very serious nature. Trees swayed violently.

Dwarahath.—Miss M. A. Seymour, M. S. Mission. Time 6-10 A.M. by clock set with mid-day gun. One severe shock. Duration 1 minute. Direction N.—S. by hanging lamp and bath. The shock and the

aftershocks were preceded by a rumbling sound like a chimney on fire. It died away after each shock. Distinctlv felt. A crack appeared in plaster and wood-work.

Azamgarh District.

Azamgarh.—Mr. W. A. Marshall, District Engineer. He was out of doors walking. The shock was not felt by him, but by a few natives. No sound.

GROUP 3.

*Gujrat District.

Aurangabad.—Mr. C. A. Colyer, A.M.I.C.E., Assistant Engineer, Upper Jhelum Canal. Time 6-18 A.M. by watch regulated by Jhelum railway station. First a feeling as if a big dog under the bed was trying to lift it up; second, a low chattering rumble like a traction engine on the Grand Trunk Road outside; third, after about half minute everything began to rattle and vibrate violently; fourth, after half minute more this was followed by a rocking motion, duration 30 to 60 seconds. Nausea produced. Direction S.S.W.—N.N.E. by rocking of bed at right angles to length and to length of house. He was impressed by the ideas that the S. wall of the room lifted up and settled down followed by the N. wall. Cracks in plaster. Clothes swung S.—N. making angle of 14° with the vertical. No objects overturned.

Gujrat.—(See p. 167.)

Gujrat City.—Gurmaki Rao, Sub-Postmaster. Time 6-15 A.M. by watch correct with telegraph time. Three shocks at intervals of nearly four minutes. Direction S.—N. by swing of door and charpoys (native bedsteads). Sound like heavy wind. No damage. All safe.

Gujrat City (8 miles N. of).—Mr. H. Martyn-Newton, L.R.C.S., Church of Scotland Mission. Time 6 A.M. by watch corrected the same day by railway time. One shock of 2 to 3 minutes' duration. Direction N.E.—S.W. Some houses fell in the town.

Jallalpur Jattan.—Time 6-20 at the end of quake. First, 6 trem. vibrations, second, 3 shocks, the 3rd dangerous. Direction E.—W. by

water of tank. Many walls of buildings fell down and many had cracks. Sound like that of carriages.

Tanda.—Postmaster. Time 6-20 to 6-27 nearly. One horrible shock.

Gujranwala District.

Gujranwala.—(See p. 165.)

Hafizabad.—Mr. E. H. Jeffries, Engineer. First, trem. vibrations for a few seconds, causing door bolts to rattle. Second, 1 severe shock of 1 minute's duration. Third, no trem. vibrations afterwards. Direction E.—W. It was distinctly felt to an alarming extent. The whole house rocked E.—W. He could hardly stand and went outside. Two meat safes suspended from pegs in the walls at right angles to each other, the house facing due N., behaved as follows: that on the E.–W. wall swung freely, that on the N.—S. wall bumped against the wall. Trees swayed. Water in channels thrown out. No objects overturned. No cracks in buildings.

Kangah-Dogran.—Postmaster. Five or 6 shocks lasting nearly 3 minutes. No damage.

Khanki.—Hony. Lieut. C. Gentry, Assistant Engineer, Lower Chenab Canal. First, no trem. vibrations before, second, very severe shocks for 5 minutes. Direction N.E.—S.W. It was difficult to stand without support. Trees shook a good deal. Cracks very numerous in kacha built houses. Pucca built houses do not show so many. The regulator at the head of the Chenab Canal cracked in several places. There was general alarm. All rushed to safe places outside buildings. Water in river a mile wide rose 6 inches immediately after the shock in 5 minutes. Water in canal 8 miles from Khanki, where there is a regulator, fell 0·20 (? feet). The canal here is about 300 feet wide and 10 feet deep. All sluice gates were open. At Sagar, 28 miles from Khanki, the water rose 0·40 (? feet). Here also there is a regulator, the canal being 200 feet wide and 10 feet deep. Direction of canal S.W.—N.E. 12 miles further on from Sagar in the same direction and 40 miles from Khanki the canal splits up into 3 branches with regulators at the head of each. Water rose 0·20 feet. These rises show that the velocity of the water in

the canal was greatly increased by the earthquake. Earth-fissures in soft ground 2 miles long on the right bank of the Chenab river 5½ miles below the Alexandra Bridge on the N.-W. Railway. There are two holes about 30 feet diameter and 4 feet deep from which fissures radiate. The largest fissures are 2 feet wide. Water in great volumes is said to have come out of the fissures (see plan, pl. 26). No sound except shaking of trees and roofs.

Khanki.—Mr. E. H. Pargiter, Superintending Engineer, Lower Chenab Canal Circle. Time 6-12 by watch, whose possible error was 2 minutes. First, no trem., vibrations before, second, a shock violently and rapidly felt for 2 minutes, and gradually decreasing in violence. Direction N.—S. by hanging lamp which with a 9 feet swing moved fully 4 feet between the ends of the swing. Walls of rest-house swayed about. Doors swung. Cracks in some houses.

Marh Balochan.—Mr. C. A. Sharpe, Assistant Engineer, Chenab Canal. Time 6-14 A.M. by watch believed to be 2 minutes fast by railway time. A rapid vibration, quickly increasing to a maximum and then gradually dying away in the course of 1 minute. He was awakened by the sideway swinging of the bed, which lay N.—S. Doors swung. No cracks seen in pucca buildings.

Ramnagar.—Aziz Ullah, Sub-Postmaster. Shock E.—W., and the N.—S. houses trembled and moved. Thundering sound heard from the east 1 second before the first shock. He was greatly alarmed.

Sangla.—L. Sahua Singh, Assistant Engineer, P. W. D. Two shocks. the first the more intense. Direction E.—W. by fall of basket and flapping of tent purdahs. No cracks, no sound.

Lahore District.

Lahore and Mian Mir.—(See p. 131.)

Ganda Singhwala.—Mr. P. Claxton, Upper Sutlej Canals. No preliminary tremors. One severe to-and-fro movement. Direction W.—E. as noted by the sound. Distinctly felt. A "chathi" of water fell from shelf 6 inches wide. It was an irregular shock with no particular direction of oscillation, but was a shake-up in every

direction. Duration a little over a minute and died away more gradually. A beam in outhouse sank 3 inches at west end owing to earthen wall giving. Sound a slight vibrating one.

Kathyala.—Mr. M. S. Dhody, Assistant Engineer, Lower Chenab Canal. Direction N.W.—S.E. Distinctly felt. He ran out of doors for safety. There was a rumble of the earth, swaying of buildings, rattling of doors, movement of trees N.W.—S.E. No damage.

Raewind.—B. Krishanchand, Sub-Postmaster. Four shocks. No effects on buildings, etc. Sound like train.

Ferozepore District.

Dhaipai near Kot-Kapura.—Mr. T. I. Dixon, Assistant Engineer. There were 4 shocks. Objects indoors danced and swung about, doors and windows flew open. Direction W.—E.(?) The big shock began gently and then got more violent. The ground heaved in an alarming way. People left their houses. It required an effort to stand. The shock ended abruptly. No cracks.

Fazilka.—Maula Buksh, Sub-Postmaster. Nine shocks as follows, first shock, duration 60 seconds. Then 2 seconds' interval. Second shock, duration 30 seconds. Then half second interval. Third shock, duration 30 seconds; followed by six shocks at intervals of half second during 30 seconds. Direction S.W.—N.E. Buildings shook like trees in a storm. Stool shook as dog underneath. Water moved S.W. Sound like dog's tail on the ground. No damage.

Ferozepore.—(See p. 159.)

Asabutai.—Mr. H. W. P. Chestrey, W. J. Canal. One prominent shock lasting 3 or 4 minutes. Distinctly felt, doors rattled, furniture rocked. House seemed to rock. Plaster fell. No damage. No sounds especially noticed.

Rasulpur (south of Ferozepore town).—Rai Sultan Singh, Sub-Engineer, P. W D., Irrigation Branch. Time about 6-13 A.M., Madras time. There were to-and-fro movements for 3 minutes. No distinct shocks. Direction N.—S. nearly. In the field "he was quite afraid the ground would split and he would go down into the cleft." Doors shook

and struck wall violently. Sound like a railway train 3 or 4 miles away noticed immediately before the shock. No cracks in buildings.

Faridkot State.

Faridkot.—Postmaster. A severe shock lasting 5 minutes. House destroyed, but no loss of life.

Faridkot City.—Mahomed Ramzam, Sub-Postmaster. He was lying down in an upper storey. There were, first, a slight tremor; second, a great shock partly divided into two parts by either a slackening in the continuous shock or a distinct break; third, distinct, trem. vibrations. Direction N.W.—S.E. It was distinctly felt. Nearly every "pacca" house in the town suffered. There were cracks in walls, minarets fell. No damage to "kacha" houses. No loss of life. Sound just before or more correctly along with the great shock, like the rumbling of a train.

Kot-Kapura.—Ramchand, Sub-Postmaster. Second shocks "hardly" (? severely) felt. Duration about 5 minutes. No damage.

Patiala State.

Bhatinda.—Maqbul Elahi, Post and Telegraph Master. There was first 1 heavy shock lasting 2 minutes. Then 1 minute interval, followed by 4 small shocks with intervals of 30 or 40 seconds between. Direction N.W.—S.E. Distinctly felt. Telegraph wires danced on posts. Waggons in railway yard were shivering. Walls trembled. Birds flew high and made much noise. No damage except few cracks. Sound like a running train, during the big shock.

Dhakal.—Two shocks distinctly felt. Direction N.—S. No effects, no sound.

Kanaud.—S. N. Chatterjee, Telegraph Master. There were 2 distinct to-and-fro movements, followed by 3 less distinct up-and-down movements. The first were fairly intense, but the up-and-down motions were not generally noticed as they were confounded with the main shocks. Trem. vibrations after for a few seconds. Direction N.—S. Telegraph table and chair rocked violently and drowned the

sound of the instrument. He thought it was a dog under the table. It was difficult to walk. A Nim tree in the garden shook violently. No objects were overturned, 2 or 3 houses were damaged. A rumbling sound like a mountain stream.

Narnaul.—Bahmukand Kapoor, Telegraph Master. One shock with swing back and forward. Fairly severe. Trem. vibrations for 2 mins. after. Direction N.—S. by a tumbler of water falling. Instrument table and shelf swung backward and forward and shook for 2 minutes. Lime plaster fell from mosque. No sound.

Patiala.—Mr. S. Brandreth, Resident Engineer, Irrigation Branch. Hanging lamps swung. A bicycle fell from its stand. Direction E.—W. by the feel of the floor. There was a continuous rumble. The quake was most distinctly felt, heard and seen. Doors and walls trembled. Nausea produced. Up and down cracks in the walls.

Patiala.—Mr. D. Farren, Assistant Engineer, Panjab Irrigation. Direction N.—S. and then almost at once E.—W. No damage. A little plaster fell. Nothing overturned, etc. Not very severe. No sound beyond doors and windows rattling.

Karnal District.

Dhanaura.—Chhajju Ram, Sub-Overseer, W. Jhelum Canal. Time 6-15 A.M. by watch compared with railway time. It was distinctly felt. Direction N.—S. He was awakened from sleep. Doors and windows rattled. Regulator gates of canal made a great noise rattling against the masonry. Canal water waved about 3 feet higher on left bank than the original surface. Canal banks cracked in several places. Fifteen springs of water burst out from the earth along 100 feet N.—S., the original spring level being 3 feet underground.

Kaithal.—Lala Daulat Ram, Sub-Postmaster. Direction E.—W. Beams in roofs fell. Many walls cracked. No sound.

Karnal.—Postmaster. Duration 45 seconds. Direction S.W.—N.E. The office rolled like a steamer at sea. Water came out of the ground in places like fountains. Several houses have fallen in the city.

Panipat.—Raja Ram, Postmaster. Duration 3 minutes 56 seconds. Very severe. Direction W.—E. It shook the buildings from their bases. Some old buildings collapsed, others cracked.

Pegan Chowki (36 miles S.W. by W. of Karnal).—Pandit Nihal Chand, Deputy Collector. Prelim. tremors felt. Afterwards 3 shocks at intervals of 10 to 13 seconds. After tremors for 1 minute. Direction N. E.—S.W. by doors and trees. It was distinctly and "hardly" felt. All houses being "one-roofed" (? one-storied) no house or part of house fell. Trees swung. In order to stand he had to keep his feet wide apart and facing N.W. On going out into the open air he heard a rumbling sound like a large humming top.

Mundri and Kaul.—Mr. A. B. Arthen. There was a tremor increasing in intensity. Direction N.N.W.—S.S.E. by hanging lamp. Damage in all the surrounding villages. All report cracks, but very few have fallen, water in buckets splashed N.N.W.—S.S.E. Rumbling sound like distant train and accompanying the first severe shock.

Shahabad.—Brij Lall, Sub-Postmaster. Direction N.W.—S.E. Distinctly felt. Damage to nearly all public buildings, Town Hall, Hospital, Railway Station. No loss of life. Many walls fell N.W. or W. and generally in 3rd or 4th stories. Earth-fissures N.E.—S.W. No sound.

Thanesar.—Telu Ram, Sub-Postmaster. Duration 3½ minutes. Crack in temple 2 inches wide. Many roofs have fallen. Telegraph pole trembled E.—W. Sound like the grinding of mills.

Muzaffarnagar District.

Khandhla.—Chainsukh, Sub-Postmaster. Six distinct shocks Direction W.—E. No sound. Upper rooms of houses, walls, etc., fell down.

Khatauli.—Har Pershad, Sub-Postmaster. Time 5-55 by time piece compared with telegraph (Madras) time. Two shocks. Movements of wall and creaking of doors. Some houses in the town fell. No loss of life.

Khairana.—Hiru Raj, Sub-Postmaster. One main shock of 5 minutes' duration. Direction W.—E. by shaking of office table. A "somewhat jingling tone felt" before the commencement of the earthquake and also afterwards. Walls of houses and iron sheet stirring.

Muzaffarnagar.—Ganesh Rai, District Surveyor. One main shock W.—E. by movements of doors, windows, etc. Distinctly felt. No sound. Door arches cracked. Walls and roofs of some houses cracked and damaged. No objects overthrown. Inspection houses at Khatowli and Pur Qazi have been cracked worst of all. Mostly the S. and W. parts of buildings affected.

Meerut District.

Aligarh.—Mr. Werner Bostron, Land Surveyor. Duration of shock 2 minutes with interval of 15 seconds. Direction W.N.W.—E.S.E. Doors slammed violently.

Babugarh.—Postmaster. One shock lasting 2 minutes, strong. Houses and trees were shaking. No damage.

Bagpet.—Sub-Postmaster. Indoors sitting. Five shocks distinctly felt with intervals of about 10 seconds between each. Total duration about 2 minutes. Direction W.—E. by guess. Sounds were noticed.

Baraut.—Newal Kishore, Sub-Postmaster. Indoors standing. He first heard rattling of window. Everything was moving. Everyone was fearful lest the house may fall. Some walls of houses cracked. Sound like a train running.

Chaprauli.—Onkar Prashad, Sub-Postmaster and Signaller. To-and-fro movements distinctly felt but not counted. He ran out of office at the shock. Direction E.—W. apparently. Telegraph wires, trees and hanging things all shook. Birds in a confused and terrible state. Pots standing one on the other fell down. Foot passengers stood still, some fell down and some could not walk. All were frightened. He sat down, praying God. Walls cracked in villages and town. No one ever felt such a shock. Old "aged souls" thought it to be their last moment. Thundering sounds during the shock.

Dhakauli (16 miles N. 60° E. of Meerut).—Mr. R. P. Atkinson, Superintending Engineer, Ganges Canal. He was in a tent, standing. Time 6-15 by watch supposed to be 3 minutes fast. One shock in three waves lasting 3 seconds. Direction N.—S. judging by the position of the tent. Very distinctly felt as it nearly upset him. Tent

ropes strained as if camels or bullocks had run into them. Rattling, rumbling sound like an unloaded country cart running down a steep bridge, perhaps 1 minute before he felt anything.

Garhmuktesar.—Ghasi Ram Varma, Sub-Postmaster. Distinct to-and-fro movements. Table and roof shook, beams and walls waved. He hastily went outside. Trees trembled nearly 5 minutes. No such shock known to the oldest inhabitants. Ganges River moved W.—E. according to hearsay. Some cracks in buildings. No serious damage.

Ghaziabad.—Postmaster. Direction W.—E. Sound like top spinning. Another report by R. Sahai, Signaller, gave the time as about 6-12 by time-piece daily compared with clock in signal room. First vibrations to and fro like train passing close by. Second, two actual shocks, and third, trem. vibrations afterwards for 1½ minutes. Direction W.—E. Utensils and clothes hanging moved. Water in jar shook. No sound.

Hapur.—Postmaster. First, a slow movement for 1 minute. Second, a severe shock for 2 minutes. Third, a slower movement for 2¼ minutes. Then, after an interval of 3 minutes, some light jerks lasting for 3 minutes. Direction N.E.—S.W. A rattling sound as of cannon discharged "far distant and dull" at the time when the shock became severe. Cracks in walls vertical from N.—S.

Meerut.—Mr. H. S. Wildeblood, Executive Engineer. He noticed, first, trem. vibrations gradually increasing. Second, shocks not counted, not particularly distinct, more a roll than a shock. Third, trem. vibrations gradually dying away. Very distinctly felt. A verandah collapsed at Major Rind's house, portico badly cracked at the Kendels and McLeans' house, church spire cracked near the top, Thomason College, W. portico, badly cracked (its tall columns being cracked vertically up the centres), and other parts, especially the arches, cracked. Rebuilding of the latter will be necessary in parts. At St. John's Church the crowns of all the arches are cracked, that between the nave and chancel has to be rebuilt.

Meerut.—Mr. R. B. Spilsbury, Assistant Engineer, P. W. D. He noticed a low humming in the air deadened by the shrieking of birds flying in an excited manner. He felt giddy. Poles of mosquito curtains waved 4 inches from the vertical E.—W. Trees also swayed E.—W. The shock appeared to be an undulation or roll. He noticed a foreshock at 2 A.M. on the same day. (See p. 356.)

Meerut.—Mr. F. A. Plomer, Overseer, P. W. D. Time 6-15 A.M. by gun time. One principal shock, a to-and-fro movement continuing for 2½ minutes. No trem. vibrations before or after. Direction E.—W. by fall of objects, water in the bath and swaying of chimney stack. He experienced the least difficulty in keeping his balance. Chimney stack 4 feet high oscillated 4 or 5 inches. Portico pillar 11½ feet appeared to oscillate 6 or 7 inches. Clay statue 2⅜ feet high on circular base of 10 inches diameter fell to the E. In his bungalow and in the charitable dispensary the main long walls running E.—W. had no cracks. But all cross walls running N.—S. were cracked at the join with the main walls. Also numerous cracks in the Tahsil. Waves in bath tub with 5 inches of water rose 3¼ inches. The sound occurred during the main shock and for 15 to 20 seconds after. It was like the low rumbling of a train. There was no sound before.

Meerut.—Suraj Boli Lal, Sub-Postmaster. There were trem. vibrations for 5 seconds, then shocks for 1 minute followed by trem. vibrations for 20 seconds. Direction N.W.—S.E. Distinctly felt. Table quivered. Doors moved to and fro, also windows opened and shut. Walls moved. Small mud jug with ball-shaped base (not flat) was circulating about its base with the hands of a watch.

Meerut.—Riaz Ahmad Hasan, Signaller. Sound like "ghur" "slowly but fearfully." One minar of the Mustafa Castle fell. One small Masjid fell.

Meerut.—Mr. W. R. Godfrey, Telegraph Master. He mentions an earth-crack 15 yards long running E.—W. in his compound. His office walls shook until he thought they could no longer stand it.

Meerut.—Lieutenant J. K. Knowles, Cantonment Magistrate. He mentions among other things a rumbling like thunder and a great wind 8 seconds before the shock,

Meerut.—Colonel W. J. Saunders, C.B., R.A.M.C. He mentions a rumbling noise like a furniture van passing soon after the commencement of vibrations. Spring mattress moved up like a boat on a wave. He and his wife left the house and stood with feet apart. Ground moved, trees swayed, houses cracked.

Sardhana.—Hira Lal, Sub-Postmaster. The shock was very distinctly felt. Direction N.—S. No sounds. Certain damage to houses is reported, walls fell at Sardhana town. The cathedral top cracked, palace injured, police and tahsil quarters damaged. The writer gives details and a plan. He felt a foreshock (?) at 5-30 A.M. of the same day (time guessed).

Moradabad District.

Amroha.—Harnam Singh, Sub-Postmaster. Two shocks, one very heavily felt and lasting one minute. Direction N.—S. No sound.

Moradabad.—Mr. J. E. Murphy, Executive Engineer, Public Works Department. Main shock of 2 seconds' duration. Direction N.—S. It was distinctly felt. Almirah in house began to sway. No damage.

Moradabad.—Syed Hamid Ali. The first shock was severe and lasted ½ minute. The Mission School entrance, gate at Tahsil and some double-storied houses were partly cracked.

Bareilly District.

Bareilly.—Mr. F. J. Laughlin, Postmaster. Indoors sitting. Several shocks with tremors lasting about ¼ hour. Hanging lamps swung about E.—W., but afterwards in a circular way, with 6 inches diameter. The shocks were distinctly felt. Chair heaved under him. On getting up to go outside he had to hold on to the table, door, etc. Outside as he was looking N. it seemed to him that the earth rose up under his right foot and rolled away as it were towards his left in a kind of wavy motion. Tall trees swayed E.—W. disturbing a number of birds in them. No damage to buildings.

Bareilly.—Mr. W. B. V. Mason, Inspecting Telegraph Master. Time 6 A.M. precisely, by clock keeping accurate Madras time, checked by

Telegraph Office the previous day. Clock stopped at 6-10, the pendulum swing being E.—W. First there was a sound resembling distant thunder, accompanied by a rapid vibration like that experienced when an express train passes a railway platform. Next a distinct shock backwards and forwards for about 35 seconds. Lastly the same sensation as at first. Hanging lamp swung N.—S. exactly, the maximum swing being about 20° out of the vertical on either side. Closed doors were dashing against each other. Chain fastenings rattled. The movement did not seem undulatory but a back-and-forth displacement of about 3 inches horizontally. Plastering fell from doorways. No cracks. Water in tub moved N.—S. and also seemed to a small extent to be swirling around.

Bareilly.—Mr. R. F. Roberts, District Engineer. Time 6-12 A.M. by watch correct with railway time.

Bareilly.—Durga Prasad Shankhadar, Meteorological Observer. He observed three distinct shocks, the second being the principal, with 20 seconds' interval between them. Direction W.—E. by tree opposite. No sound. Giddiness during the second shock. Cracks in N.W.—S.E. walls of Bareilly College and High School, also in N.—S. walls of Town Hall, and in N.—S. walls of Kotwali building.

Pilibhit District.

Pilibhit.—Postmaster and Signaller. Three shocks and trem. vibrations for 90 seconds after. Direction N.W.—S.E. by hanging lamp. Three cracks in upper story. Water in tank in great mosque moved and flowed outside (overflowed).

GROUP 4.

Hazara District.

Abbottabad.—Conductor B. Crowhurst, Telegraph Master. One shock lasting nearly two minutes. The worst he has experienced there where earthquakes are frequent. No trem. vibrations noticed before or after. Direction E.—W. by chimney, the loose stones of which fell E. Motion like a springless cart with loose axles. A succession

of bumps and jars. Beams of roof creaked. Shingles of roof clattered. Old earthquake cracks opened again. Falls of plaster occurred. Hanging lamp suspended by thick wire tied round a beam running E.—W. had much vertical motion. Dancing best describes the motion [NOTE.—This evidence of vertical motion so far from the epicentre is a little strange.]

Haripur.—Mahomed Amir Ali, Signaller. Time 6-15 by telegraph time-piece. About 4 shocks. Direction N.—S. Trees moved heavily. He left his house immediately. No damage. Cracking of windows and doors.

Mansehra.—Karim Bux, Postmaster. Time 6-20 by watch compared with telegraph clock. No trem. vibrations noticed. Five shocks. Trem. vibrations after for five minutes. Direction N.W.—S.E. Distinctly felt. Only earth fell from the roof. No cracks.

Attock District.

Attock.—Major W. K. Hardy, R.Y.A., Commanding at Attock. Time about 6-10. He was indoors lying down. No distinct shocks. Trem. vibrations only. Distinctly felt. Walls of Serai, 6 feet thick, vibrated distinctly.

Campbellpore.—Goven Dhan Dass, Sub-Postmaster. He was indoors working. Two shocks of trem. nature, duration 2 minutes. Direction E.—W. Roofs made a noise, and there was great fear in all minds. No objects overturned. No cracks. All hanging articles swung freely.

Fatehjung.—Jagar Nath, Sub-Postmaster. Indoors lying down. First, several trem. vibrations, second, number of prominent shocks not counted, but each increased in intensity. Total duration about two minutes. Direction S.W.—N.E.(?) Thundering sounds heard under the earth. Distinctly felt. Buildings shook severely, but no damage. No objects overturned, no cracks, etc.

Rawalpindi District.

Ghora Galli.—Sergeant D. Kay, Meteorological Observer. He was lying in bed. There were two shocks, the first of which seemed very

heavy. His bed rocked like a cradle. When walking he felt as if treading on a number of inflated balls. The second shock was of equal intensity. Duration 10 to 30 seconds. Direction N.—S. No damage. A grating sound at the end of the shock.

Kohala.—Postmaster. One shock, shutters trembled, verandah also. Telegraph wires jingled. Trem. vibrations after for about 5 minutes. Houses, trees and telegraph posts all in tremulous condition. He ran downstairs.

Murree.—Telegraph Master. Time 6-16 A.M., Madras time, usually two or three minutes fast. One shock followed by slight tremors for 60 seconds. Direction E.—W. Doors and windows creaked and rattled slightly. No damage.

Rawalpindi.—Lieutenant-General Sir B. Blood, K.C.B., Commanding Northern Forces. He was asleep in bed. Time 6-9 within a minute or two of error. There was one prolonged shock. A north door rattled and woke him. There was the usual rumbling sound. Roofs, doors and windows rattled. A packed portmanteau lying N.—S. rocked rather violently. Duration 1½ to 2 minutes. A pendulum clock facing W. stopped at 6-9. Another clock of the same kind facing S. did not stop.

Rawalpindi.—Maya Dass, Postmaster. Duration 3 minutes. Direction S.—N. A few lofty houses in the town cracked.

Rawalpindi City.—Postmaster. Duration 5 minutes. Three buildings fell.

Rawalpindi City.—Mr. G. W. Holley, Military Telegraphist. Duration 1½ to 2 minutes. A few cracks in one bungalow of 9th Lancers' Lines. Direction N.—S. apparently.

Rawalpindi.—Mr. R. A. Munro, Sub-Assistant Superintendent, Telegraphs. In bed lying down. Time 6-11 at end of shock by timepiece set by time signal from Madras Observatory at 16 hours the previous day. One shock. Direction N.N.W.—S.S.E. Duration 1½ seconds. No sounds.

Tret.—Kashi Pershad, Sub-Postmaster. The earth quaked here nominally for a few seconds. No damage at all. Hardly felt.

Jhelum District.

Dandot Mine.—Mr. D. Thomson, Mining Manager. Time 6-15 to 6-18. There was a broken window and some plaster fell. Some rocks fell on the hill side. In the mines it was not felt at all at 300 feet depth.

Jhelum City.—B. Jowinda Mall, Sub-Postmaster. Five or 6 shocks at intervals of 2 or 3 seconds. Direction N.E.—S.W. Some buildings in the city cracked. Doors knocked.

Jhelum.—Rev. R. Stewart, D.D., American United Presbyterian Mission. First, prelim. tremors were felt. Second, 2 or 3 main shocks with intervals of perhaps 5 to 10 seconds. It was the hardest shock ever felt by him. Doors rattled but no damage. It was hard to continue standing. He and his wife were both dizzy. (The writer gives details of houses belonging to the Mission in Dharmsala damaged.)

Jhelum.—Mr. J. T. Farrant, Superintending Engineer, Upper Jhelum Canal. First a severe shock followed by gradually decreasing vibrations. Direction N.—S. by water in a basin. He thought he was being rudely shaken by some one. Roof creaked. No cracks caused.

Jhelum.—Lieutenant-Colonel J. H. Balfour, 13th Lancers. Time 6-20 A.M., N.-W. Railway time, checked on the 7th. Duration ½ to 1 minute.

Khewra (at the Mayo Mine).—Mr. H. A. R. Lyon, Superintendent and Manager. Forty seconds' duration. Several shocks were felt for some time. A few buildings were cracked, but none fell. Underground in the mines it was felt but there was no damage. The mine is 500 feet at the deepest. [NOTE.—Hitherto earthquake shocks have not been felt in a mine, but it should be remembered that these mines are of the nature of chambers cut out of the side of the hill and not mine sunk below the ordinary level of the country.]

Nurpur Mines.—The Superintendent (name illegible). The mines were not working at the time of the earthquake. No effects were however discovered afterwards. No effects either above ground.

Pind Dadun Khan.—Ram Datt, Sub-Postmaster. Four trem. vibrations followed by 1 principal shock of 2 minutes' duration. No trem.

vibrations after. Direction S.E.—N. W. by hanging lamp. Window boards and walls were moving to and fro. He went tumbling, and the rupees which he was counting fell.

Shahpur District (Punjab).

Wan.—Mr. A. J. Gibbs, Assistant Engineer, Jhelum Canal. One shock. Direction W.—E. Distinctly felt. Not alarming, he did not leave the house. No effects. No sound.

Khushab.—Lachman, Assistant Surgeon, Civil Dispensary of Mianwali. No prelim. tremors. Three principal shocks, the first being the strongest. Distinctly felt. Chains swung. Walls of houses vibrated. One could not stand erect on the ground. No sound.

Kot Nafa.—Mr. E. L. Glass, Assistant Engineer. Two distinct shocks. Trem. vibrations after each shock for about 1 minute. Direction E.—W. by doors. All doors and windows rattled. No sound.

Sargodha.—Ram Labhaya Mall, Postmaster. Three principal shocks. N.E.—S.W. No damage. Sound like "calm storm."

Sargodha.—Mr. J. Middleton, Assistant Engineer. One continuous shock at first rapid to and fro and gradually getting slower but larger oscillation. Three and a half minutes' duration Direction W.—E. by punkah and by water in irrigation channels. It was distinctly felt. He went outside hastily. After the shock there was a tidal wave came down the canal N.—S. No sound.

Shahpur.—Pastmaster. A slight shock. Duration about 2 minutes. No sound, etc.

Warcha (Mine).—Mr. G. Wilson, Manager. No effects were noticed below ground nor above except by a few natives. The miners' houses are very frail and if there had been any shock to speak of some traces would have been left.

Jhang District.

Jhang.—Mool Chand, Postmaster. Time 6-10 by Post Office clock. Three shocks. Direction N.—S. It was distinctly felt, but there was no damage.

Chiniot.—Postmaster. Duration 4 minutes. Direction N.—S. The building was shaken violently, but there was no damage.

Montgomery District.

Dipalpur.—Postmaster. One shock. Direction E.—W. Hardly felt.

Kamalia.—Ram Brosa, Sub-Postmaster. Time 6-18 A.M., Madras time, by telegraph clock corrected the previous day at 4 P. M. No prelim. tremors. Two distinct shocks with 30 seconds' interval, the second being more severe than the first. No tremors after. Direction E.—W. It was distinctly felt, no such earthquake having occurred here since many years (50 or 60). The ground moved distinctly. Houses were shaken. No damage. No cracks, no objects overthrown, no sound.

Montgomery.—Raushan Din, Head Clerk, Civil Surgeon's office. He felt, first, trem. vibrations, second, 4 or 5 sharp shocks in an E.—W. direction, third, trem. vibrations for 5 minutes. It was distinctly felt. The chain of door moved. Doors rattled and hanging lantern swayed vigorously E.—W. There was an unusual barking of dogs heard the night preceding the earthquake. No cracks. No objects overturned. Rumbling before the shock rather like a railway train in the distance and it lasted until the main shock was over.

Hissar District.

Bhiwani.—Nihal Singh, Sub-Postmaster. Two prelim. tremors. Table and lamp were "shocking" tremulously. One main shock of 3 minutes' duration. Direction E.—W. by lamp and office table (?). Few houses cracked. No sound.

Hansi.—Babu Shadilal, Sub-Postmaster. Time 6-13 by telegraph office clock. First, continuous, sudden thunder as if railway train passed by. Second, 1 severe shock of 3 minutes' duration. Third, 2 slight shocks of ¼ minute each. Direction N.E.—S.W. by fall of wall and hanging iron rod. Some houses cracked and a three-storied house fell. The telegraph line moved to and fro.

Hissar.—Gujar Mall, Supervisor, P. W. D. Time 6-15 by clock always compared with and corrected by local railway station. First, several trem. vibrations not counted. Main shock direction N.W.—S.E. Very severe. Several two-storied houses cracked slightly here and there in the city.

Sirsa.—Hira Singh, Sub-Postmaster and Meteorological Observer. Time 6-10, Madras time, by watch. Three shocks were felt. The couches swayed, he was aroused from slumber and ran out. Direction N.—S. Fall of top of chimney of Railway Institute. Slight cracking of dome of mosque. Sound resembled boiler discharging steam and was simultaneous with the shock.

Sirsa.—Mr. A. P. Varma, Assistant Engineer, Canals. He was asleep and did not feel any prelim. tremors. Two main shocks, the first distinctly felt for nearly 2 minutes, second, about $\frac{3}{4}$ hour afterwards. Direction N.—S. by punkah swinging. Rattling of doors and gentle rocking of bed awoke him. The punkah moved. No sound.

Jhind State.

Sangrur.—One continuous shock with 2 maxima. Duration 3 minutes. Direction W.—E. Articles were thrown E. A very severe shock. A two-storied house, substantially built, a mass of cracks from roof to floor, the cracks being 1 inch across. A piece of the upper story parapet 12 inches cube on E. wall was detached and flung clear of the verandah and lodged 10 ft. off the building. Roof plaster fell in large quantities. The Maharaja's *Diwan Khana*, a massive building about 90 feet high, was a mass of cracks, some gaping rents a few inches wide at top. Candle chandeliers with 30 feet suspension lost their candle guards which were strewn in broken glass on the floor. Birds, especially pea-fowl and crows, during the shock kept up a continuous and awful shrieking.

Sangrur.—D. Ramchander, Telegraph Master. Time 6-9 A.M. by stopped clock. Duration 2 minutes. Direction S.—N. No sound. Distinctly felt. A severe shock. Office buildings shook S.— N. No damage to office.

Rohtak District.

Beri.—Dalu Sabaj, Sub-Postmaster. About 12 shocks. Table shook, also hanging lamp. Trees shook. Only one upper story house was cracked. No sound.

Gahana.—Ragbhar Dial, Sub-Postmaster. Four shocks lasting 10 minutes. Direction N.W.—S.E., first shock severe, the others slight. No damage, etc. Sound "like clouds."

. *Jhajjar.*—Shekh Ashref Ali, Overseer. About 3 shocks, the second being the most severe. Direction E.—W.(?) It was distinctly felt. The ground appeared to rise up and sink with a shaking to and fro E.—W. Walls and roofs swung. No objects overturned. No cracks. No sound.

Kalunaur.—Jawarbarlal, Sub-Postmaster. Two shocks lasting a few seconds. Trem. vibrations for 3 minutes after. Direction N.—S. Distinctly felt. A little earth fell out of roof, doors moved. No other damage. No sound.

Rohtak.—Hira Lal, Postmaster. One shock for 2 or 3 minutes without any interval. Direction E.—W. Very distinctly felt. Difficult to stand without support. Lamp would have fallen if he had not taken it from chimney and put it on the ground. No other effects. Sound like a train.

Rohtak Mandi. —Shankslall, Sub-Postmaster. Time 6-13 by time-piece compared with Madras time. Twelve shocks lasting 4½ minutes. Direction W.—E. Distinctly felt. Roof and chair creaked. Sound as "slight hollow."

Delhi District.

Delhi.—Sub-Postmaster of Dareeba. He was indoors working at the mail. Time 6-15 A. M. by office clock regulated daily. There were 3 shocks of nearly 2 seconds each. The first shock was felt with great "tramming." Direction N.E.—S.W. Tables moved. Cracks in Head Post Office. Turret of fort fell. Water of tank of Jama Masjid came out. Some cracks in tomb of Humayan.

Delhi.—Mr. C. Debenham. Indoors lying down. Time 6-12 by clock which stopped, corrected daily with time from Observatory. One

very severe shock only. Direction E.—W. Cracks in post office. He did not hear any sound himself others did.

Delhi.—Ramsaran, Sub-Postmaster, Maiden's Hotel. Time 6-10 to 6-13. One shock, very dangerous. Direction E.—W. Serious damage to houses without loss of life. No sound.

Delhi.—Mr. D. J. Lavelle, Executive Engineer, Provincial Division in Civil Lines near the Ridge. He was in bed asleep. Time 6-09 A.M. (? 6 hours 9 minutes). First, a steady severe rumbling ending in 2nd a sharp shock. Direction N.—S. by the senses. He was aroused from sleep. Door rattled, etc. Cracks in buildings.

Delhi.—Azizud Din, Sub-Postmaster, Sudder Bazar. He was indoors standing in upper story. Time 6-30 A.M. by Bee time-piece confirmed daily at 4 P.M. Four principal shocks, 2 of which were trem. vibrations. Direction W.—E. by hanging lamp. Very distinctly felt. Much damage to houses.

Delhi.—Ram Rachpal, Sub-Postmaster, Chouri Bazar. Time 6-12 (guessed). Three principal shocks. Fuel on roof sounded.[1] He first thought it was a "monkey walk."[2] Again the fuel sounded tremendously, and he was certain it was an earthquake.

Delhi.—Chanan Ram, Sub-Postmaster, Chandni Chouk. Time 6-10 by time-piece not compared. Three shock E.—W.

Delhi.—K. M. Abdal Majid, B.A. Time 6-11 by pendulum clock which stopped (trustworthy). Three shocks at intervals of 3 seconds. Direction E.—W. Sound like country carts on rough road heard before each shock.

Delhi.—Nathou Lal, Head Clerk, Civil Surgeon's Office. Time 6-10 A.M., Madras time, by clock kept correct with railway time. Fifteen to 20 shocks at 2 seconds' interval. Direction N.—S. (?) Buildings were seen tottering. Articles on shelves did not fall. In town very few houses are said to have cracked. A sound was "felt" before the main shock at intervals of 2 seconds.

[1] In many parts of India wood fuel is piled on the roof to dry.

[2] Refers to the fact that monkeys frequently gambol over the roofs in Delhi and other towns where they are sacred and protected animals.

Bulandshahr District.

Bilaspur.—Mr. W. A. Kinloch, Manager, Fargus-Skinner Estate. Time 6-15 A.M. by large pendulum clock stopped (railway time). There was, first, a rumbling sound like thunder increasing rapidly. Beds, screens, almirahs and pictures swayed to and fro. Windows rattled and also glass doors like castanets. We rushed out to the lawn keeping our feet with difficulty. Huge trees swayed and hanging baskets of ferns from N.—S. Duration 2 minutes. It was succeeded by a few small shocks. Large cracks in walls of single-storied pucca buildings. Fowls and frogs have cried day and night since and before the occurrence.

Bulandshahr.—Pandit Lakshmi Shanker, District Surveyor. Time 6-12 A.M. by clock correct with clock tower. Three shocks distinctly felt. Duration 2 or 3 minutes. Direction N.W.—S.E. Bed shook, he went out. Trees shook heavily N.W.—S.E. Slight crack in church tower, canopy mortar fell. Another observer noted a slight whistling sound.

Sikandrabad.—Hargian Singh, 2nd Master, High School. Time 6-15 A.M. clock compared with Post Office clock the previous day. Three shocks: first at 6-15, second at 6-18 and third at 6-20. Direction S.E.—N.W. Sound like a mail train. Bed swung, shutters of doors and windows struck against each other. He left house and saw a boy running towards him and stumbing as he went. No serious damage. Cornice of wall fell in another house.

Budaun District.

Budaun (at Kheri village near).—Hire Khan, Supervisor, District Surveyor, P.W.D. There were trem. vibrations for 2 or 3 minutes. Then a severe shock of 10 seconds' duration and then trem. vibrations again continuing for 10 minutes after. Direction E.—W. No particular sound. He was standing in the N. verandah and saw houses bending to the W. and the cracking of doors and roof timbers was heard. Water in a well moved E.—W. against the walls. Hanging flower pot moved E.—W.

Shajahanpur District.

Rosa.—Shanki Day, Sub-Postmaster. Three shocks each lasting 1 to 1½ seconds. Direction E.—W. No sound. Everything shook. A palm tree remained shaking for a long time.

Shajahanpur.—Mahomed Ali, Sub-Postmaster. Time 6-15 by watch corrected the day before at 4 P.M. by Madras time. Three shocks in 3 minutes. Direction W.—E. by branches of trees. His bed began to move from W.—E., he was sitting on it facing S. Creaking sounds and rustling of trees prevented him hearing any peculiar sounds. Budhi Ram, Overseer, P.W.D., also recorded the shocks as, first, very slight, second, which occurred 3 seconds afterwards, very distinct and lasted 4 seconds, third very slight. Direction N. W.—S. E. No sound. During the second shock the whole house distinctly moved N.—S. A brass lota fell down from wall platform to S.

Tilhar.—Postmaster. Three shocks.

Kheri District.

Kheri.—Postmaster. Two shocks lasting 40 seconds S.—N.

Lakhimpur.—Mr. R. K. Mosely, D. S. P. Time 6-10 by railway time. He was indoors in bed. Two shocks with hardly perceptible interval S.—N. Bed tilted, feeling of nausea. Trees rocked about. No sound.

Lakhimpur.—B. Shiam Manshar, Sub-Postmaster and Signaller. Time 6-15-0 to 6-15-40 A.M. by time-piece always compared with Madras time. Two shocks, S.—N. by water in tank and lamp. No sound.

Wesleypore.—Mr. G. E. Claxton. Time 6-15 A.M. by pendulum clock stopped. One shock lasting a little over 3 minutes. Direction E.—W. by hanging lamp. Doors rattled and walls swayed slightly, but not enough to affect pictures and ornaments.

GROUP 5.

Chitral.

Chitral.—Mahomed Bux, Telegraph Master. He was indoors sitting. Time about 6-15. Duration about 25 to 30 seconds. There were 2 shocks in quick succession, the first being of greater intensity,

Direction N.W.—S.E. Rumbling noise just before first shock. None after. Distinctly felt but slight. No damage, etc.

Drosh.—Habibul Rahman Khan, Telegraph Master. He was indoors lying down awake. Time about 6-10 Madras time. There was one shock lasting 2 minutes. Direction N.E.—S.W. It was distinctly felt. No damage except to loose stone walls.

Mastig.—Usman Ghani, Telegraph Master. He was lying down asleep. Time about 6-15 A.M. No trem. vibration before. There were 3 shocks, the first being the most severe and lasting for 15 seconds. Direction from Chitral to the Pamir. Doors moved to and fro slightly. No damage, no cracks, etc. His cot moved slowly but heavily. He notes that earthquakes are common here and he has felt 4 or 5 in the last 9 months.

Dargai.—Mr. W. Grover, Military Telegraphist. Time 6-15 A.M by telegraph clock. He was lying down indoors. 1 shock hardly felt lasting for 1 or 1½ minutes. No sound.

Peshawar District.

Charsadda.—M. Allah Din, Postmaster. He was indoors lying down. There were 3 shocks, slow in beginning and rapid at the end. Direction N.E.—S.W. It was distinctly felt, but only a little harder than an ordinary earthquake. No damage, etc. No sound.

Cherat.—Mr. C. O'Connor, S. D. O. He was indoors moving about. The shock was very slight, scarcely noticeable.

Jamrud.—Babu Mangal Singh Garanthi, Sikh Priest. He was indoors sitting. A slight shock. His cot swayed slightly for ½ minute. No sound. Clothes hanging on ropes moved E.—W.

Landi Kotal.—Jagat Singh, Sub-Divisional Officer, Khyber Military Works. Time 6-18 by watch compared with a recognised standard time clock. No prelim. tremors noticed. Two shocks with interval of 20 seconds. Trem. vibrations after for 10 seconds. Doors and windows clattered. Direction E.—W. Distinctly felt. Distant sound between main shocks like railway carriage approaching.

Landi Kotal.—Guran Ditta Mall, Sub-Postmaster. Indoors lying down. Time 6-18 by office time-piece generally corrected at 4 P.M. Two shocks with interval of 10 seconds the first being the more intense. Sound before main shock like distant railway train.

Mardan.—Mr. R. H. Tickell, Executive Engineer. Indoors lying down. He noticed, first, a trembling and vibration for 1 minute, second, a violent upheaval for 2 minutes, third, milder vibrations dying away. Direction E.—W. judging from polo sticks swinging on several walls. Slight nausea. No sound. An officer in the Guides says it was quite a mild shock compared with other shocks experienced here. No damage.

Nowshera.—Mr. E. Tydeman, Sub-Engineer, Military Works. Time 6-7 by watch set by gun time. He was indoors lying down. One shock only. Tremors after for 1 minute. Distinctly felt as in a boat when moved by a swell.

Peshawar.—Major N. J. D. Dundee, R.E. Indoors lying down. Prelim. tremors not felt as he only woke towards the end of the shock. Pictures on walls running N.W.—S.E. were crooked after the earthquake. Those on N.E.—S.W. walls were not displaced. A fairly good shock. No damage. No sound.

Peshawar.—Mr. C. Cuerden, Military Works. Indoors lying down. Time 6-20 A.M. according to local gun. He first felt a simple vibration, second, a to-and-fro movement like a ship, third, a jerky vibration gradually subsiding like an express train. Direction N. 23° W. A pair of binoculars on wall swung parallel to it. Doors and windows rattled. A rumbling sound lasting 30 seconds simultaneous with first vibrations.

Peshawar.—Mr. W. P. Carr, Telegraph Master, Lahore, was communicating at 6-14 when the telegraph suddenly ceased to work. One strong shock of 2 minutes' duration. Direction E.—W. Cot moved, also hanging lamp. Sparrows flew out of roof in a body. Doors croaked and vibrated. No damage. No sound.

Shankargarh.—Kashi Singh, Head Master. A slight shock for 5 minutes. Bed moved. No curiosity in this place.

Malakand.—Sergeant P. McCarroll, Telegraph Master. One slight trem. vibration. Direction N.—S. apparently. No damage, etc. No sound.

Chakdara.—Mr. A. Colman and Mr. J. Mullar, Military Telegraphists. One shock. Charpoys shook. No damage. After the shock there was a "roll through the ground" lasting 2 seconds.

Kohat District.

Fort Lockhart.—Postmaster. Very slight shock of 2 or 3 minutes' duration. No loss, no injuries.

Parachinar, Kurram Valley.—Mr. S. Waterfield, Political Agent. Time 5-50 by watch and carriage clock correct 3 days before with railway time at Thal. There was, first, a long roll, second, a pause with tremors for a few seconds, third, a long roll. Direction N.W.—S.E. It was distinctly felt as if in a swing going dead slow. It awoke him, but he did not get out of bed. The house shook and the rafters creaked. No sounds.

Kohat.—Lieutenant C. Reed, R.A. One principal shock followed by trem. vibrations for 2 minutes. It woke him. No sound, etc.

Kohat.—Major H. A. Magrath, 51st Sikhs. He was indoors lying down. Time 6-15 by watch proved 5 minutes fast by gun time. There were prolonged trem. vibrations, which after 2 minutes reached their maximum and then died away. Duration about 4 minutes. No definite shocks felt. Direction N.W.—S.E. by bird cage. It was slightly felt. No sound.

Warshand.—Amin Chand, Village Postmaster. He was sitting outside. There were 3 shocks, very weak, and with 1 second intervals. Direction E.—W. by his feelings. Articles trembled slightly. As he sat he was much moved as to his upper part as if nodding in sleep. No sound.

Lachi.—Postmaster. It was not felt by him. A few others felt it. Duration 4 to 5 seconds.

Sadda.—Ali Akbar Shah, Postman. He was indoors and lying down. The shock was felt once.

Thull.—Telegraph Master. The shock was not felt.

Mianwali District.

Kalabagh (Salt mine).—Mr. C. H. J. Orchard, Superintendent. A severe shock of 1 minute's duration. The waters of the Indus were disturbed and ran up the banks. In the mines (which are really open quarries) there was no damage except earth falling.

Mianwali.—B. Balsarup. Three distinct shocks of 3 minutes' duration. No damage. No sound noted. It was a severer shock than ordinary.

Multan District.

Multan.—(See p. 182.)

Ilampur (16 miles N.E. of Multan).—Mr. C. S. Faddy, Executive Engineer, Multan Canals. There were 2 principal shocks with trem. vibrations between and after the second, the whole lasting 1½ seconds. Direction N.W.—S.E. The intensity was great. The sling chains of office camp doors rattled, etc. Table oscillated. One large fissure in the house. No sound.

Bannu District.

Bannu.—Capt. E. Kirkpatrick, 59th Scinde Rifles. He was indoors in an upper storey. Time between 6-30 and 7. There were, first, small tremors, second, larger tremors, third, small tremors again, the whole lasting for 1 minute. Direction E.—W. by bottles hung on nails. No sound. Slightly felt.

Bannu.—Mrs. E. F. Pennell. She was indoors sitting. Time 6-25 A.M. Simple vibrations, somewhat distinctly felt. Direction W.—E. by water in bathing tank, and N.—S. by chain hanging.

Bannu.—Mr. E. M. Prescott, Telegraph Master. Felt by him about 6-15 A.M., but not noticed by the majority of people.

Boya.—Girdhari Lal. Two principal shocks. No damage, etc. A small sound between the shocks.

Datta Khel (Tochi Valley).—Rala Ram, Sub-Postmaster. Several shocks. Direction E.—W. No sound, no damage, etc.

Miranshah.—Sheikh Allah Buksh. Two slight shocks. Direction E.—W.

Miranshah.—One big continuous tremble. People woke up from shaking beds. No sound.

Idak.—Daulat Ram, Postmaster. Three shocks at intervals of 1 minute. Direction S.—W. (*sic*). Very slight. No damage.

Khajuri.—Ram Singh, Branch Postmaster. Three shocks. Charpoy moved to and fro N.W.—S.E. Duration 4 minutes. Distinctly felt. Articles and telegraph instruments seemed moving. No damage, etc. Sound like light phaeton passing.

Dera Ismail Khan District.

Bund Karai.—Mr. E. S. Bellasis, Superintending Engineer, Punjab Irrigation. He was in a tent in bed. Time 6-15 about. Distinctly felt, bed shook for 5 to 10 secs.

Darahan.—Sukh Dial, Postmaster. He was lying down. Time between 6-25 and 6-30 A.M. There were, first, 4 trem. vibrations, second, 2 principal shocks of 2 minutes' duration, third, trem. vibrations for 4 minutes. Charpoy moved E.—W. and towards the N. No sound.

Darazanda.—Amar Nath, Sub-Postmaster. Indoors sitting. Time 6-7 by office watch. Four shocks, the first severe lasting 1 minutes, the others ½ minute each. The third was a small one, but lasting about 3 minutes. Direction W.—E. by clothes on pegs. No sound.

Dera Ismail Khan.—Palamal, Telegraph Master. Indoors sitting. Time 6-15 A.M. by office clock. First, a rattling of doors, second, several shoks lasting over 1 minute. Direction E.—W. Distinctly felt. No damage.

Kotla Lodian.—K. B. Sher Muhammad, Assistant Engineer. He was sitting in the verandah. One shock lasting 3 or 4 minutes. Distinctly felt. No damage, etc. No sound.

Kulachi.—Bhagat Sudaman, 2nd Master, D. B. School. Two shocks with 30 seconds' interval, slight. No damage, etc.

Tank.—Ghulam Hussain, Reserve Signaller. Indoors lying down. Three slight shocks in 3 minutes. Duration, a few seconds each. No damage. No sound.

Wano.—The Political Agent. Time about 6-0 A.M. Slight.

Nilikuch.—Postmaster. Not felt.

Dera Ghazi Khan District.

Kharr (near Fort Munro, Suleiman Range).—Mr. H. S. Cassen, Deputy Commissioner, Dera Ghazi Khan. He felt nothing personally, but the earthquake was said to have been felt in the Suleiman Range and at Harrand, 40 miles S. of Fort Munro. There were cracks in the military post (badly built) in the centre of the Suleiman Range. It was hardly felt.

Taunsa.—Gulam Nabi, Sub-Postmaster. Indoors sitting. Time 6-10 (guessed). One shock lasting half a minute. Slight. No damage.

Dera Ghazi Khan.—Mr. D. M. Stewart, Assistant Engineer P. W. D. Indoors lying down. A continuous vibration for 2 minutes. Direction N.—S. by doors. No damage. No sound.

Lyallpur District.

Bachranwala Canal Inspection House.—Mr. W. H. Mills, Executive Engineer, Lower Chenab Canal. He was in a tent. What seemed like a high wind woke him, doors and window purdahs flapped. His bed rolled E.—W. It was lying N.—S. No damage to buildings at Bachranwala.

Chiniot Road.—Karm Narain Kapur, Sub-Postmaster. Direction N.—S. by doors.

Kanya Canal Rest House.—Bhagwati Prasada Varma, C.E. Time 6-14 A.M. by watch compared with railway time at Lyallpur on 8th April. Prelim. tremor not noticed. Two shocks at intervals of a few seconds, the second shock the more intense and lasted longer than the first. Trem. vibrations after for ½ minute. Direction E.—W. and 2 minutes' duration. Others say the direction was N.E.—S.W. He thought it was a dog under the bed. Tables, doors, etc., shook. Pictures on walls oscillated N.—S. No cracks, etc. Two almirahs hanging on pegs in W. wall were thrown down. His clerk sitting in the fields facing W. noticed the wheat about 4 feet high being bent down as if by

an invisible roller. There was no wind at the time. There was a light rumbling sound, faintly distinct like the rustling of trees during the shock.

Khiderwala.—Mohamed Nosib, Canal Signaller, Lower Chenab Canal. A few trem. vibrations followed by 3 shocks. Direction N. W.—S.E. It was distinctly felt. No cracks in any building. No sound.

Khikhi (canal building).—Raghbir Singh, Deputy Collector. Two distinct shocks. No damage, no sound.

Lyallpur City.—Mr. P. A. Hindley, Assistant Engineer, P. W. D. Irrigation Branch. Trem. vibrations for about 30 seconds, followed by 2 distinct vibrations of greater magnitude in opposite directions of 4 seconds duration each. Trem. vibrations for about 30 seconds. Direction N.E.—S.W. and then back again. It was distinctly felt. Doors and windows rattled, clothes on pegs swung. Water in bath nearly slopped out. He was nearly shaken off the side of the bed. No cracks, etc. Probably a rumbling sound.

Lyallpur.—F. W. Carne, Executive Engineer, P. W. D., Irrigation Branch, Lower Chenab Canal. Direction N.E.—S.W. The undulations were very distinctly felt. Bed rocked. He went outside on hearing something fall. Duration 1 minute. He leant on S.W. wall and distinctly felt its rocking movement. Nothing overturned, etc. No cracks except in the house of the Deputy Superintendent of Police. No damage in the city. No sound.

Tarkham.—Mr. H. Banerjee. No prelim. tremors noticed. Six shocks, the third being the most intense and altogether lasting 3 minutes. No vibrations after. Direction 230° 30′ by hanging lamp. Distinctly felt, nothing overturned, no cracks, water agitated. Deep growling sound heard by some.

Ugbana.—Mr. W. F. Smith, Chenab Canal. Time 6-5 A.M. by watch set by railway time at Lyallpur on the 2nd April. One shock lasting about 40 seconds. Direction E.—W. by water in bath. Distinctly felt. Bed shook violently. His bearer almost fell down. Doors rattled, cooking pots on shelves were precipitated to the ground. He went out of the house. No cracks in buildings. A slight rumbling sound about 5 seconds after he felt the shock and it lasted for 10 to 15 seconds.

Bikaner State.

Bikaner City.—Diwan Chand, Compounder and Meteorological Observer. Time 6-14 by watch compared with railway station clock (noted in note-book on the day of the earthquake). He was indoors sitting. Two shocks from N.—S. and *vice versâ* after an interval of a few seconds. It was distinctly felt.

Bikaner City.—Mr. A. W. S. Standley, Executive Engineer. He was indoors lying down at first in upper storey 21 feet above ground. He got up and walked into the next room, then the movement ceased. The shock was a continuous vibration lasting 1½ minutes. Direction E—W. or W.—E. The greatest movement at 21 feet above ground was ½ inch, *i.e.*, ¼ inch each way. Tiles rattled in E. and W. verandahs. No sound. Nothing overturned or damaged.

Ratangarh.—Officiating Sub-Postmaster. Indoors sitting. "Con tinual shocking about 3 minutes. No intensitive shock but slow." Lamps and almirahs moving slowly. Sound like grinding stone.

Sardanshahr.—Postmaster. Time 6-13 to 6-16 by clock in Telegraph Office. One shock was felt. There was a thundering sound. Office and window doors were quaking, tables and chairs felt moving. No damage.

Sujangarh.—Gograjmal, Postmaster. At first indoors, afterwards outside. One shock for about 5 minutes Distinctly felt. Trem. vibration for about 2 minutes afterwards. Direction W.—E. No sound.

Jaipur District.

Bissau.—Ramchandra Dhuinsory, Postmaster. One prelim. vibration, 3 minutes' shock. Distinctly felt. Direction N.—S. Only a thrilling sound.

Chirawa.—Pundit Shirshanke Dube, Postmaster. One principal shock lasting 10 seconds and another lighter than the first. Total duration 2 minutes. Direction N.W.—S.E. The first shock was like a running train at full speed for 3 or 4 seconds, this was followed by a continued trembling for 5 seconds more. Then the other shock came lighter than the first. Water in cooking pots moved S.E.

Fatehpur.—Sridat, Postmaster. Time 6-10 A.M. by office clock stopped. The shocks continued for 5 minutes. Office walls, tables, chairs and stools, etc., all moving. Direction from S. distinctly. Sound like "stone mill from the window shackles of my telegraph office." No damage. He and the signaller and clerks ran away and stood outside the office.

Jaipur.—Mr. A. H. Garton, Telegraph Master. Time 6-25 A.M., Madras time, clock checked daily from Madras. There was first a sound like a rushing wind from the S. (no wind outside), next 3 principal shocks, the third being very slight. Distinctly felt. Duration 15 seconds and with 15 seconds interval. Direction W.—E. by door which opened slightly. No damage.

Jaipur.—Nathu Narain, second observer. Time 6-15, Madras time [10 minutes difference between this estimate and the last]. It was noticed indoors, upstairs, but not out of doors. No damage to buildings, but in the registration of the anemograph the pencil appeared to have risen slightly and marked a straight line over previous registration.

Jhunjhnu.—Krishnarao, Postmaster. Time 5-55 by telegraph clock keeping Madras time. One shock, 5 minutes duration. Direction N.—S. There was a sound during the shocks. Distinctly felt. Rather severe. Three houses in the city were damaged.

Khotri.—Amir Baksh, Officiating Signaller. Shocks lasted about 3 minutes. Direction W.—E. by hanging lamps. Sound a small roaring sound like wind. All things in the office shivered. Telegraph instruments made a slight noise. Water in tank and bath tubs shook as if someone had thrown stones into it.

Kotputli.—Bankey Lal, Signaller. Time 6-11 by telegraph clock. Two shocks. Iron chains of door and parcel scale moved. Sound like thunder at the beginning of the shock. Tower near tank outside town broken.

Lachmangarh.—Harman Singh, Postmaster. About 4 or 5 distinct shocks. No damage.

Mandawar.—Narayan Krishna Chiney, Postmaster. Two shocks like a train departing from a railway station. Doors and windows

rattled in the same way. No sound. Slight damage to a fort called Gadh.

Nawalgarh.—Gopal Panchuram, Postmaster. A continuous shock or shocks for 6 minutes. Direction N.—S. Distinctly felt. Sound like a "blow of wind of low degree." Trees and buildings all were moving. Wall of building rent and fallen down.

Ramgarh.—Gulab Rai Varma, Postmaster. Time 6-8 A.M. to 6-10, clock daily compared with Ajmer clock. Two shocks, the first being severe. Direction S.E.—N.W. A very loud sound "felt" about 10 seconds before first shock. Very distinctly felt. He thought it was a passing carriage at first. Tables, scales, doors and chairs were trembling. All in the office left work and began worshipping as it seemed that the whole building would collapse. They were too frightened to go out. It was the severest shock ever felt by any of them. No damage.

Sikar.—Sub-Postmaster. One shock distinctly felt. No sound.

Surajgarh.—Pannalal Sharmah, Sub-Postmaster. One shock for 5 minutes. The bed trembled. No sound noticed. A mud wall 15 feet by 5 feet by 1 foot fell towards W.

Alwar District.

Alwar.—Captain Garrett, R.E. Indoors lying down in an upper storey. Distinctly felt as a series of vibrations for a minute or more. 2 or 3 finials on the City Palace fell in an E. or S.E. direction. Cracks only insignificant. No sound.

Kishengarh.—Lala Nand Kishore, Naib-Tehsildar. In the open air standing. One shock of 2 minutes' duration and with trem. vibrations for 1 minute afterwards. Direction W.—E. Hardly felt. A loud noise before the shock and peacocks were crying.

Jhana Ghazi.—Ahmad Said Khan, Hospital Assistant. Three shocks of 4 or 5 minutes' duration. His cot moved, doors made a noise. No sound.

From the towns of Bahror, Mandawar, Kathumbar, Gobindgarh, Lachmangarh, Ramgarh similar brief reports have been received indicating a shock or shocks during varying periods and with no sound.

From Rajgarh came the statement that the noise was like a gun afar off.

Gurgaon District.

Palwal.—Karam Chand, Sub-Postmaster. Two shocks. Some buildings in the city got damaged. Some people got up and out into the air, hanging lamps, chains, walls and couches moved. No sound.

Bharatpur State.

Bharatpur.—Rev. J. M. Paterson, M.A., C.M.S. He was indoors lying down in an upper storey at the first shock. Half an hour later at the second shock he was sitting. At the first shock houses swayed a good deal for 3 minutes. Direction N.W.—S.E. Doors and windows rattled and in 15 to 20 minutes the houses began to sway. A sensation of giddiness was produced. Damage done was a crack in arch of S.E. room, extension of cracks in chimney, plaster of walls cracked in corners and round beams.

Bharatpur.—Mr. J. A. Solomon, Hospital Assissant. Time 6-10 by a clock which is always compared with telegraph office clock. Four trem. vibrations before the first shock. Vibrations after the principal shocks felt for 30 seconds. Direction E.—W. Sound like railway train before the 1st shock. Water in moat of fort disturbed for an hour or so after the shock. Hanging lamps and earthen pots disturbed for some time.

Bharatpur.—Shiam Lal, Overseer, P. W. D. He was indoors standing. Time, at 6-10 A.M. railway time. He felt a shock, after 20 seconds a severe shock when buildings began to shake. Duration of this 30 seconds. Then, after ? seconds' interval, another severe shock lasting 4 minutes decreasing in force gradually to the end. All were within 5 minutes. Direction N.—S. by hanging rope. No sound.

Dig.—Bhagwalpershad, Signaller. Indoors sitting. Three distinct shocks as follows: 6 to 6-1 slight, 6-1 to 6-2 stronger, and 6-2 to 6-4 slight.

Muttra District.

Brindaban.—Badir Prasad, Sub-Postmaster. One shock, duration 3 minutes. Distinctly felt. Punkah was moving N.—S. No sound.

Gokal.—Syed Taj Ammul Husain. One principal shock W.—E. Distinctly felt but caused no damage.

Kosi.—Pandit Ram Krishna Rao, Sub-Postmaster. Time 6-20 A.M. by time-piece compared with office clock keeping Madras time. Duration 15 minutes (*sic*). Direction S.E.—N.W., later E.—W. It was distinctly felt. Everything in the office and house in a shaking condition but nothing fell. There was a rumour that some houses fell in the city.

Muttra City.—Lukhpat Ray, Overseer. Time 6-10 A.M. by watch corrected 3 or 4 days before with railway time. There were, first, trem. vibrations, then 1 shock and later trem. vibrations lasting 8 seconds nearly. No sound. The seat shook. He thought it was a dog underneath. A Nim tree was shaking.

Aligarh District.

Aligarh.—Radhamohan Lal, Postmaster. Office clock stopped at 6-12. One shock, not severe. Duration 1 minut. Directione E.—W. Chair and table were "shocking," lamp trembling, water in tub shaking. Beds of children were "shocking." No damage.

Aligarh.—Ambuj Nath Mukerji, Apprentice Engineer. First, a rocking movement, second, 10 or 15 principal shocks with intervals of 1—1½ seconds. Direction E.—W. No damage, no sound. It produced dizziness. Punkah frame, walls, doors and windows vibrated.

Hathras.—Ducan Lal, Sub-Postmaster. 6-17 A.M. by office clock stopped. Three distinct shocks during 32 seconds. Direction N.—S. No sounds.

Sakandra Rao.—Badri Prasada, Sub-Postmaster. Two shocks were felt.

Agra District.

Agra.—Chimonlall. Time 6-16 A.M. by telegraph watch. One shock distinctly felt. Duration ½ minute and 2 others not distinct. Direction W.—E. All the buildings were seen to shake.

Agra.—Lukshmi Ram Pandya, Observer. Time as above by watch compared with gun fire. Two shocks distinctly felt. Duration ½

minute. Direction N.W.—S.E. by articles hanging on pegs. No sound. No buildings destroyed, nor chimney fell. A few cracks in arches. Spire of St. Paul's Church shifted on base at a height of 8 feet from the top. All pendulum clocks stopped.

Dholpur.—Mato Pershad, Sub-Postmaster. One shock, the door was once shaken.

Kalpi.—Postmaster. One shock slight lasting 55 seconds.

Kotla (*near Ferozabad, E. I. R.*).—Mr. F. E. Place. Two shocks. Lamps and punkahs swung 5 inches W.—E.

Etah District.

Etah.—Jagat Narain, Supervisor, District Surveys. Time 6-12 A.M. by clock compared with Telegraph Office and gun fire. He was indoors standing. The shock was distinctly felt. Hanging lamp 3 feet 5 inches from point of suspension oscillated nearly 9 inches.

Mainpuri District.

Mainpuri.—Bhagut Singh. Indoors standing. Three shocks distinctly felt with 20 seconds intervals. Direction N.—S. No sound.

Mainpuri.—Pandit Benaprosad, Sub-Overseer, P. W. D. Indoors sitting. Time 6-15 A.M. by clock corrected 2 days before with Telegraph Office clock. One light shock lasting 2 to 3 seconds. Direction W.—E. Closed doors made a noise, bed moved very slowly.

Shaikohabad.—Murli Dhar, Sub-Overseer, P. W. D. Time 6-12 to 6-14 by watch compared with East Indian Railway time. Three vibrations S.—N., the first movement lasting 40 seconds, the second shock 15 seconds, and the third movement being instantaneous. Doors "chattered," bottles on shelf moved at their tops. Brass-ware in basket had a slight motion.

Farukhabad District.

Fatehgarh.—B. Chhajju Singh, Postmaster. Three shocks at intervals of 2 or 3 seconds. Duration 20 seconds. He felt dizzy and saw table and chair shaking. Other observers describe it as a severe shock with continuous vibrations for 30 seconds or as 4 or 5 uniform shocks lasting 2 minutes. Do rs rattled, roof creaked. No damage.

Farukhabad.—M. Ram Lal. Four shocks of uniform force. Bench trees, room shutters trembled. No sound.

Tripaulia Muhalla.—P. Badri Narayan Misa, Deputy Inspector of Schools. Trem. vibrations distinctly felt for 2 minutes. Direction N.—S. Doors and chains clanked. Trees quaked and walls waved.

Hardoi District.

Hardoi.—Postmaster. One shock 1 minute's duration. Punkah moved E.—W. for about a minute.

Shahabad.—Officiating Signaller. Five principal shocks each lasting minute, each accompanied by 3 shocks lasting 20 seconds each. Direction E.—W. The shock was distinctly felt for 5 minutes.

Sitapur District.

Sitapur.—Mr. W. B. Partridge, Deputy Commissioner. Two very light shocks felt at an interval of 4 or 5 seconds. No sound, nothing fell. Bed shook (he thought it was an animal underneath at first). A box balanced on a pile of newspapers did not fall.

Sitapur.—Mr. J. Sykes, District Surveyor, P. W. D, One continuous series of vibrations lasting about 30 seconds. Also Mr. A. Chunderkunar, Post and Telegraph Master, gives the time as 6-13 A.M. by office clock regulated daily at 4 P.M. There were 2 distinct shocks lasting for about 2 minutes. A pile of books fell to W. Mr. W. F. Martin, D. S. P., also describes 1 shock lasting 10 to 15 seconds with rumbling sounds. He first thought it was a dog under the bed.

Sultanpur.—Mr. R. F. Young, District Superintendent of Police. Three shocks at close intervals. No trem. vibrations distinctly noticed. Duration of each shock 10 to 15 seconds. Direction N.—S. by punkahs. No sound noticed. [*N. B.*—The punkah which swung was hanging E.—W. Others at right angles did not swing but the ropes vibrated.]

Bahraich District.

Bahraich.—Syad Zahur Ahmad, District Surveyor, P W. D. He was indoors sitting at the first shock, afterwards on roof of house. Time

6-15 A.M. by watch and clock keeping telegraph time. Two shocks Direction E.—W. by hanging lamps and bath tubs. Doors, bolts, chain, trees and lamps "shocked." Other observers in this town simply describe the shock as slight.

Nanpara.—Tulsi Ram, Sub-Postmaster. One principal shock distinctly felt which lasted for some three minutes. Direction from "N.W. side" judging by loose objects hanging indoors. No sound. No damage.

GROUP 6.

Jaisalmer District.

Jaisalmer—Lala Bag Nath Nazim. Six slight shocks, N.—S. Distinctly felt, bed moved. No sound, no damage.

Jodhpur, or Marwar, District.

Barmer.—Munshi Aḥsanali, Postmaster. Three shocks, the first and third intense. Duration 5 minutes altogether. Direction N.—S. No sound.

Barmer.—Kunwar Hem Singh, District Officer and Magistrate. One shock and continuous trem. motion for 5 seconds. Punkah moved a little. Sound a deep thundering just before the shock.

Didwana Salt source.—Mr. A. E. Cline, Assistant Commissioner, collected the information. He himself did not feel it. Several people sitting or standing were rocked to and fro. Three distinct shocks within 3 minutes. Distinctly felt. Loose bolts in doors rattled. Direction N.—S. Of two eight-day clocks facing S. and E., respectively, the one facing S. stopped, the other was not affected (the pendulum would be stopped by a N.—S. movement). A dull rumbling noise just before the earthquake. Weevil-eaten rafters 5 feet by 3 feet snapped and fell through ceiling cloth. Arches over doorways were affected (cracked), those facing E.—W. more than those facing N.—S.

Jodhpur.—Capt. S. H. Jacob, Assistant Resident, W. Rajputana States. Time 6-5 by a reliable watch set by railway time a day or two before. A trem. vibration which awoke observer. Bolts rattled, windows rattled and bed shook. Punkah oscillated due N.—S. Three

or 4 inches. It was 10 feet long and the suspending rope about 6 feet. No alarm. No sound.

Jodhpur.—Pandit Narbada Prasad Bharqava, Meteorological Observer. Time 6-14 A.M. by watch compared with railway clock, correct. One shock felt. Doors shook and also window panes and an almirah for 2 minutes with an up-and-down movement and also a lateral one (N.—S). A rumbling noise during the main shock. No disturbance in the trace of the barograph and thermograph.

Pachbadra.—Mr. C. H. Holford, Assistant Commissioner, N. I. Salt Revenue. He was indoors sitting. Two gentle oscillations each lasting about 20 or 30 seconds with short intervals between. Direction E.—W. No sounds. Distinctly felt. Braces hanging from pegs swayed.

Pokaran.—Rorhan Lal Udawat, Hospital Assistant. Indoors lying down in bed. Two shocks, the 2nd being the more intense with an interval of 2 seconds or so. Distinctly felt as something (*e.g.*, cats) under the bed. Tables and bottles in the dispensary shaking, but nothing upset.

Sambhar.—Mr. W. Lyon, Assistant Commissioner, Salt Revenue. Indoors sitting. Time about 6-10 by railway time. Two distinct shocks, the first having a duration of about 1 minute. It was noticed by rattling of doors. The 2nd about 10 minutes afterwards and lasted a few seconds. No sounds.

Sajat.—Pandit Hazarilal Sharma, Head Master. Indoors lying down. Two distinct shocks, first duration 2 minutes, interval 3 minutes, second, 2 seconds.

Sirohi District.

Mount Abu.—M. M. Talati, Meteorological Observer. Indoors lying down. 6-50 A.M., Madras time, by clock not compared. No shock was felt by observer, only a rumbling sound from W.—E. lasting a few seconds. On the same date at 6-17 and at 10-21 A.M. there were similar rumblings. Dogs barked at the sound. [There is a note added by the Superintendent to the effect that he doubts the strict accuracy of the above because earthquakes are of such common occurrence there

that no particular notice was taken of this one—nevertheless see next form which confirms the above.]

Mount Abu.—Captain P. P. Kilkelly, I.M.S., Civil Surgeon. He was indoors lying down at first, afterwards standing up. Three shocks about 6 A.M. distinctly felt with 40 to 50 seconds interval. Direction S.W.—N.E. judging by the sound. The shocks were accompanied by a noise like a train or distant thunder, so that he got out of bed to see if a thunder storm was approaching. This observer also mentions the aftershock at about 10-15 A.M. which was most severe, the room shook, articles rattled and he was about to leave the room when it ceased.

Ajmer-Merwara District.

Ajmer.—Ram Pershad, Meteorological Observer. Time 5-53 local standard time—6-15 Madras time. Two main shocks, each 1 to 2 seconds and with 2 or 3 seconds interval. He first noticed cot in verandah moving slightly. Next, objects on table rattling and vibrating and then falling, the direction of fall being E.—W. taken from a glass phial 3 inches long which fell. [With reference to this statement Major W. R. Wortbest, I.M.S., Superintendent, Meteorological Observatory, adds a note saying that he does not credit it.] No sound. No damage.

Ajmer.—Pandit Brij Jiwan Lal Sarma, B.A., Tehsildar. Time 6-17 A.M. He was indoors sitting in second story. One shock of 2 minutes' duration. He first thought it was something wrong with his head and so lay down on the ground. His body still moved E.—W. No damage. No sound.

Ajmer.—Rai Bahadur Pandit Sham Nath, Executive Engineer. He was sitting on a chair in upper verandah. No distinct shocks but a continuous shivering. Trembling of closed doors and windows. Nothing damaged, etc.

Ajmer.—Major W. R. Wortbest, I.M.S., Superintendent, Meteorological Observatory. Two main shocks, distinctly felt, which woke him up. Felt by most people in Ajmer.

Beawar.--Ishan Tosh Mittra, Assistant Surgeon. He was roused from sleep by a rumbling sound, which he recognised at once as an earthquake. He got up and was leaving the room when it stopped. His bed quivered, window shook terribly. It continued for 4 or 5 seconds with no distinct shocks. No damage.

Deoli.—Captain C. E. Tristram, 42nd Deoli Regiment. He was lying down in bed in upstairs room. Trem. vibrations for 90 seconds. A bamboo teapoy and candlestick on it quivered perceptibly. No sound. The door facing E.—W. has now lost its set and so scrapes the ground when closing.

Kishengarh State.

Kishengarh.—Mehta Daulutsingh Diwanji Mohulla. One shock E.—W. Bedstead was noticed to be shaking, also observer's body, etc. No sound. No damage.

Tonk District.

Tonk.—Captain A. B. Drummond, Political Agent. He was indoors lying down. Time 6-25 A.M., Madras time (watch compared on 5th instant with railway time at Jaipur station). [The time given is probably a mistake for 6-15.] There were a series of sharp vibrations sufficient to rouse one from sleep. Duration 20 to 25 seconds gradually ceasing. Water in tumbler vibrated. A very distinct rumbling sound during the shock.

Mewar District.

Shahpura.—Poundarik Pandit Chatra Datt. Six or 7 shocks. Direction W.—E. by hanging lamps.

Udaipur.—Not felt.

Karauli State.

Karauli.—Pandit Raghunath Prasad. Slight shocks lasting only a few seconds. No trem. vibrations. Hardly felt. No damage.

Kotah District.

Baran.—G. C. Jagtap, Postal Signaller. Two shocks at intervals of 2 seconds. Locks of boxes moved, also chair. No sound. Only felt by a few.

Bundi.—Generally observed by those lying down. One shock, very slight, lasting a few seconds. Hardly felt. No sound. No damage.

Kotah.—Major A. D. Bannerman, C.I.E. Political Agent. One slight vibration lasting nearly 1 minute. Direction. S.W.—N.E. Only felt by a few. Iron bedstead shook. Few loose stones on parapet of city wall fell. No sound.

Kotah Cantonment.—Major P. J. Lumsden, I.M.S. One shock consisting of trem. vibrations for about ½ minute. Direction W.—E. Panes of glass rattled. Distinctly felt. He thought it was some dog scratching himself under the bed.

Jhalawar State.

Jhalrapatan.—Manna Lal, Rajput. Three distinct shocks. Water in well bubbled, turned muddy and burst into foam. Duration 3 or 4 minutes No sound.

Etawah District.

Etawah.—Mr. A. Cairncross, Sub-Conductor, District Surveyor. Time 6-9 by watch often compared with railway time. The shock was not felt by himself, but by his wife who recognised the character of the shock. Bed swayed. Doors rattled. No loose objects fell. No sound. It was also felt by the servant.

Etawah.—Mr. G. H. Kitching, Station Master, East Indian Railway. Time 6-13 to 6-15 A.M. He was standing on the platform at the time and noticed the time from the station clock. One shock. Roof of corrugated iron sounded as if a man were running with haste along it. Direction W.—E. by the swinging of platform lamps. Nothing overturned. No cracks. No sound except that of door and roof.

Jalaun District.

Kadaura.—Mum Taz Hosain, Sub-Postmaster. He was indoors sitting. A sensation of movement from N.—S. Two shocks at an

interval of 2 seconds. No sound. Time 6-30 compared with Cawnpore.

Kalpi (*Orai*).—Azmat Ali, Postmaster. One shock, duration 55 seconds. Corrugated iron roof of ginning factory in a rattling state. Water in reservoir shaking from E.—W. Most people could not feel the shock. No sound heard.

Kunch.—Shivkam Pandya, Sub-Postmaster and Signaller. He was sitting indoors. Three distinct shocks N.W.—S.E. Distinctly felt. Chains of doors shook and utensils in a basket struck each other.

Orai.—Mr. E. F. Hilton, District Surveyor, P. W. D. He was indoors lying down. One trem. movement, no separate shocks, 30 seconds' duration. Direction N.E.—S.W. Doors swung and rattled gently. Cracks in residence of Special Judge of Orai. No sound.

Machli Shahr.—Abdul Basir, Sub-Postmaster. One shock lasting few seconds. "Not hardly felt."

Mungra Badshahpur.—Lala Satnarain Lal, Sub-Postmaster. He was standing indoors. One shock slightly felt N.—S. His feet trembled as if he were about to fall. Hasps of doors rattled slightly. Water at Laloo's tank shook N.—S. Clothes swung from pegs.

Cawnpore District.

Cawnpore.—Mr. A. D'Moriar, Deputy Telegraph Master. Time 6-15 A.M. There was first a slight to-and-fro movement for 1 minute, second 2 prominent shocks at 2 and 3 seconds' interval, the first being of greater intensity. No trem. vibrations noticed afterwards. Direction W.—E. apparently.

Cawnpore.—Radha Krishna, Agency Clerk, Government Telegraph Office. Indoors sitting in third story of the house. Time 6-15 A.M. by clock now and then compared with gun time. Shocks strong at first and distinctly felt and afterwards dying down. Lasted about 3 minutes in all. Direction W.—E. Faint rumbling sound during the shock. House shook slightly, things rattled and fell (a clock fell). Coats and clothes swung from pegs.

Unao District.

Unao.—Postmaster. Duration about 1 minute. Furniture shook, room had a circular motion.

Unao.—Pandit Basheshar Nath, Supervisor, District Surveys and P. W. D. Time 6-15 A.M. by watch corrected with railway time. One shock E.—W. Hardly felt. No damage.

Lucknow District.

Lucknow.—Rev. R. M. Kirwan, Garrison Chaplain, Dilkusha. Time 6-15 A.M. by watch correct with Oudh and Rohilkhand Railway station. Two principal shocks of equal intensity from E.—W. with interval of 15 seconds followed by a third from N.—S. of lesser intensity after the same interval. No sound, but the rustling of trees simultaneous with the shocks. The shock was very distinctly felt. His bed appeared to be rolling, also the house. Plates and dishes rattled, but nothing overturned. No cracks in buildings. Hanging lamp swung violently E.—W. One man in barracks told the observer that he saw the shock coming in the form of a wave from over a hundred yards.

Lucknow.—Ram Dayal, Sub-Postmaster. He was indoors standing. He first felt some " round movement," then felt falling down towards the N., then stood tightly and again felt falling. Chair shook N.—S. He ran out of the house. " Round movement " and shocks all felt about 2 minutes only. No sound.

Lucknow.—Mr. J. F. Jackson, Traffic Sub-Assistant Superintendent. He was indoors sitting. Time 6-15 to 6-16 Madras time. First 2 trem. vibrations, second 2 shocks with 2 seconds' interval, the first being weaker than the second, but both feeble. Direction N.W.—S.E. He was sitting with his back to the W. and the second shock lifted him forward and the point of his pencil broke. No sounds.

Sitapur.—Head Signaller. Two shocks lasting 2 minutes. Twenty large ledger books fell down at the first shock.

Bara Banki District.

Bara Banki.—Postmaster. Indoors sitting. Four or five shocks distinctly felt. Direction N.—S.

Gonda District.

Gonda.—Kali Charan, Postmaster. He was indoors sitting. A slight shock for 3 or 4 minutes. He felt his body shaking and thought it might be his state of health. But others felt it. Windows and doors shook. No damage.

Hamirpur District.

Hamirpur.—Mr. H. E. Miller, District Surveyor, P. W. D. He was indoors lying in bed. A series of trem. vibrations of a somewhat severe nature. Very distinctly felt. Punkah rocked visibly S.E.—N.W. Vibration lasted about 30 seconds. A low rumbling sound as of distant thunder.

Fatehpur District.

Fatehpur.—Rev. C. H. Mattison, A. P. Mission. First trem. vibrations very distinctly felt. Then 3 distinct bumps like a dog under the bed, the second being the heaviest. Doors and windows rattled, walls and punkahs swayed. Centre wall of mud, 20 feet high and 3 feet thick lying N.E.—S.W., was cracked vertically.

Fatehpur.—Mr. A. C. Walker, I.C.S. Two distinct series of shocks, the first being the more intense, and minor subsequent vibrations. Chain vibrated N.—S. Giddiness produced. Doors standing open shook 2 inches or so. Old cracks in walls reopened.

Rae Bareli District.

Rae Bareli.—Postmaster. One slight shock for 5 to 6 minutes. Direction W.—E.

Fyzabad District.

Fyzabad.—Rev. J. F. W. Gompertz, Chaplain. Time 6-13½ to 6-15 by watch constantly compared with railway time and an excellent time-keeper. First door of bedroom rattled and woke him, second beds shook and knocked against each other. The shock lasted roughly 1½ minutes. A slight rumbling sound. A number of other observers mention similar phenomena varying slightly. Many describe 1 shock only and no sound. The shaking of furniture is commonly recorded, whilst one mentions the fact that cracks formed by a previous earth-

quake of a few years ago did not reopen. Trees swayed as in a high wind.

Basti District.

Basti.—Mr. K. R. Chatterjee, Assistant Engineer. Trem. vibrations. He was awakened by the clattering of windows and doors.

Basti (Civil Lines).—Captain G. T. Carroll, Civil Surgeon. Trem. vibrations for about 10 seconds, with to-and-fro movements. Distinctly felt. Direction E.—W. by water in tub. He felt giddy, others felt the same and one lady believed she was going to faint.

Banda District.

Banda.—Lala Chhote Lal, Assistant Engineer. He was indoors moving about, first shock lasted 1 minute, second shock after ½ minute's interval and lasted ½ minute. It was feebler than the first. He only heard a rattling of window shutters at first and thought it was wind and then (seeing there was no wind) a lizard. Only afterwards he knew it must have been an earthquake.

Banda.—Mr. G. T. Barlow, Executive Engineer. Time given as 6-15 in one form and as 6-20 in another, 2 distinct shocks lasting a few seconds with ¾ minute's interval. Direction N.W.—S.E. No sound. Vibrations were rapid and felt as though his heart was beating against something hard, and then as if the ground was moving rapidly under him. Noticed by several.

Allahabad District.

Allahabad.—Mr. F. Taylor and Mr. J. S. Durack, Meteorological Reporter, record the shock. Three people's testimony gives the time as 6-15 A.M., railway time. No one was awakened. No damage. The shock was a gentle tremor hardly felt.

Meaghergunj and Sarsa.—Not felt.

Partabgarh District.

Kalakankar.—Jainte Prasad Kumreya, Officiating Sub-Postmaster. One shock, chain shook, trees trembled and swayed. Duration 1 minute.

Partabgarh.—Mahommed Ibrahim Khan, Signaller. He was in the open air sitting on the ground. Three slight shocks, 1 to 2 minutes' duration. He first thought it was a "weakening of his mind." Direction N.W.—S.E. "The sound of birds, who used to utter early in the morning, was not so sweet that day before the earthquake."

Partabgarh.—Mr. E. Hill, Special Manager, Court of Wards. Three distinct shocks. The first felt like a dog under the bed "scratching and heaving me up." It was of a few seconds' duration. Then an interval of 20 seconds, second there was a more vigorous shaking which revealed to him that it was an earthquake. Thirty seconds' duration. Then followed 15 to 20 seconds' interval, and, thirdly, a table in the verandah began shaking. A square horizontal frame of iron rods hanging from the ceiling swayed N.N.W.—S.S.E. The suspending cords were 14 feet long and the movement was 6 to 8 inches from the vertical. No sound.

Mirzapur District.

Chunar.—Bishambar Nath, Signaller. One shock only, very slight.

Mirzapur.—Mr. W. H. Clifford, Executive Engineer. Shocks very slight in the early morning.

Gorakpur District.

Gorakpur.—Matilall, Officiating Telegraph Master. He was indoors sitting. No trem. vibration at first. The office floor seemed to shake. His wife confirmed this by observing water in the bathroom visibly shaking for 5 seconds. Direction W.—E. by men's statements. Hardly felt.

Gorakpur.—Mr. J. Gilmore, District Surveyor, P. W. D. He was in the open air driving. He did not feel the shock, but on arriving at the Kapti River at 6-20 he was informed by a number of people that a tidal wave had been observed, and he saw the marks of the crest line on both banks. Also at Ami River where he was building a bridge he was told that water in the bridge foundation wells was much agitated, spilling over the top E.—W.

Gorakpur.—Mr. J. F. C. Davis, Commissioner. He was indoors lying in bed. There were two perceptible tremors lasting 1 second each with an interval of 5 seconds. It is described by the writer as being about No. 2 or 3 of the Rossi-Forel scale of intensity [in which conclusion I think he was right].

Deoria.—Mr. W. C. C. Francis, P. W. D. Time 6-16 A.M. by watch compared evening before with railway time. Duration 18 seconds by counting. Five distinct shocks with about equal intervals. Direction W.—E. by punkah and water in bath.

Benares District.

Benares.—Jogindra Nath Mukerji, Telegraph Master. Time 6-15 by telegraph clock regulated daily by Madras. One shock N.—S. slight. No apparent motion or displacement of objects.

Ghazipur District.

Ghazipur.—Mr. C. H. Burt, Sub-Divisional Opium Agent. He was indoors lying down. Two distinct tremors, the second being the more severe with an interval of 10 seconds. Direction N.—S. by punkah. [All punkah-derived directions are necessarily untrustworthy as the punkah has a tendency to swing in one direction only.] The shock woke observer up and he first thought it was a dog scratching himself against the bed post.

Ballia District.

Ballia.—Mr. B. K. Mukerji, Assistant Surgeon. One shock distinctly felt. Heavy iron bed rocked, E. door rattled. No sound.

GROUP 7.

AFGHANISTAN.

Jellalabad (in the Nimla Bagh).—Mr. H. Dobbs, with the Kabul Mission. He was in a tent, lying down in bed. About 5-30 Kabul time. There was first a distinct up-and-down movement of bed lasting ¾ minute. No sound. No damage.

Baluchistan.

Quetta.—Shiawakshaw Pherozeshaw, Government Contractor. Time in the morning. Felt very slightly. No cracks, etc.

Quetta.—The Civil Surgeon. Not felt.

Dhadur (near Sibi).—Major H. L. Showers, Political Agent. Not felt.

Khost.—Manager, N.-W. State Railway. Not felt, but a lady at Sharig, 10 miles away, felt it slightly.

Bombay.

From the province of Bombay we have only received a few earthquake forms, frequently not more than one for each district. Most of these therefore may be grouped together. Forms from the following places recorded that the shock was not felt:—Bombay town itself, Kolaba (although Mr. N. A. F. Moos, Director of the Government Observatory, has furnished a full account of the seismographic record, see p. 290), Deesa (Palanpur District), Karachi, Veeraval (Kathiawar District), Malegaon (Nasik District), Hyderabad (Sind), Jacobabad (Shikarpur District), Sind. Subjoined are summaries of forms sent in from places where the shock was more or less felt.

Ahmedabad City (Ahmedabad District).—Amichand Ambalal Modi, Head Clerk, Municipal Resident's Office, and Meteorological Observer. Time about 6-10. There were 2 or 3 to-and-fro movements as "if he had faints." Direction N.—S. judging from the flow of water in tanks. It was hardly felt. Partition walls, 9 inches thick, in the middle of water tanks of mills fell down about 8 feet from top towards S. Tank water overflowed towards S.

Ahmedabad City (Ahmedabad District).—Mr. A. R. Spencer, Assistant Engineer, P. W. D., also gives further details of these tanks. They were 150 feet across. The partitions were 13½ in. thick, of burnt brick and lime masonry, and the water on each side of the partition was at the same level, kept so by connecting arched openings. The water is described as having first risen on the N. side, then heaved to the

opposite direction. The partition walls fell in each case (of 3) to the S. Time about 6-8 (guessed).

Ahmedabad City (*Ahmedabad District*).—Mr. W. Doderet, Collector. Time between 6 and 6-30. He heard that a slight shock was felt, but he did not feel it himself personally as he was asleep in bed. He mentions that a mill-wheel was lifted off its level, and that small ablution tanks in a *masjid* in the city were emptied of their water.

Bhuy (*Ahmedabad District*). —Not felt.

Faizpur (*Khandesh District*).—Bhandor Digambar Rangari. Time about 6-25 A.M. He was indoors sitting. One shock of 2 seconds' duration. Direction W.—E. Hardly felt. Hanging lamps moved back and forth. No sound.

Gandevi (*Navsari District, Baroda State*).—Sub-Postmaster. Time between 6-10 and 6-15 A.M. The windows shook and there was some little sound heard before, very slight.

Kadi (*Baroda State*).—The Assistant Civil Surgeon. Time between 6 and 6-15 A.M. He was indoors sitting. There was first a slight downward movement followed by an upward one. Then there was one shock, direction uncertain, hardly felt. Hanging lamps were seen to move and also water in tank.

Nadiad (*Kaira District*).—Dayabhai Bhavanishanker, Post and Telegraph Master. Very slight shock, almost imperceptible. Clocks, etc., did not stop.

Patan City (*Baroda State*).—Pundit Girdhar Lal, Raj Guru of Jhalawar. He was sitting indoors before sunrise. There were two different shocks felt with 2 minutes' interval. Direction N.E.—S.W. Books in notches turned topsy-turvey.

Rander (*Surat District*).—Mahomedans praying in a *masjid*. Time about 5-30 to 6, Madras time. One shock. Direction E.—W. Distinctly felt. Water of Hoz flowed E.—W. Hanging lamps struck against each other. Duration 1 minute.

Sadra (*Mahikantha District*).—Ambalal Rouchlod, Maistry, P. W. D Time about 6-15. He was indoors sitting. There were about 15 prelim.

tremors then a big shock and then 15 vibrations after for 10 seconds. Loose shutter and bamboo mat made a noise.

Surat (*Surat District*).—Byramji A. Nandati. Time about 6 A.M. (guessed). There were 2 or 3 shocks at intervals of about 30 seconds. Direction E.—W. Slightly felt.

Tando Masti Khan (*Khairpur State, Sind*).—Mr. E. H. Corridon, Sub-Assistant Superintendent, Survey of India. Time 6-11½ A.M. by railway time at the beginning of the tremors and 6-49 at the end. The tremors were not sensibly felt, but were observed from the movements of the bubble in a level tube. The maximum deflection of 30 seconds of arc occurred between 6-20 and 6-25 and it increased again at 6-35. The direction of the motion was not determinable, the instrument showing about the same amount of deflection when held N.E.-S.W. as at right angles to this. No sound. These details were corroborated by Sub-Assistant Syed Zille Hassair who set up his level at right angles to Mr. Corridon's.

Vadanagar (*Ahmedabad District*).—Lalubhai Desai, Sub-Postmaster. Time 6-30, about. One indistinct shock. Loose objects hanging on wall fell. No sound.

CENTRAL INDIA.

Baghelkhand Agency.

Nowgong.—Sarat Chandra Dey, Head Clerk to Settlement Officer. He was indoors lying down asleep. Time shortly after 6. No trem. vibrations before the shock. Two shocks, the first very severe, the second a light one within the space of about 2 minutes; there were trem. vibrations between and after the second shock. Duration about 3 minutes. Direction about N.W.—S.E. by swinging of the bed, and N.—S. by the fall of glasses. House utensils leaning against the walls fell down. A sound of "Gurr-r-rh" at the beginning of the earthquake.

Sutna.—Not felt.

Baoni District.

Kadaura.—Ambaycharan, Head Master, Ang.-Ver. School. Time about 6 A.M. He was standing on the roof. Two shocks within 4 or

5 seconds. It was distinctly felt. Trem. vibrations lasted 2 seconds. Direction N.—S. No sound.

Bijawar State.

Bijawar.—Gajadhar Prasad, Sub-Postmaster. Time about 9 A.M. [this is rather late for even a guess]. He observed a bubbling and spreading of water in a tank. Direction W.—E.

Bundelkhand Agency.

Jigni.—The Jagirdar of this place reports earthquake at daybreak. Direction N.—S. No damage done.

Sarila.—Pandit Raghunandan Dikshit, Kamdar of the Sarila State. One slight shock felt distinctly. Door shutters made a slight rattling noise. No sound.

Alipura.—Rao Bahadur Chhatr Pati, C.S.I., Rajah of Alipura. He was indoors lying down upstairs. Time 6-5 A.M. by "clock correct with sundial, showing Madras time." Two distinct but slight shocks at intervals of 1 second. Iron bolt of window shook violently for 3 seconds. Direction E.—W.

Alampur.—Reported by the Indore Durbar. Time about 6-30 A.M.

Gwalior State.

Bhilsa.—G. P. Misra, Postmaster. Time 6 A.M. (guessed). Indoors sitting. There were prelim. vibrations to and fro. Then 3 shocks very light followed by trem. vibrations afterwards for 2 minutes. Direction S.—N. by movements of water. No sound.

Morina Railway Station.—Har Sahai Lall Varma, Sub-Postmaster and Signaller. Time 6-12 to 6-13 by Railway Telegraph Office clock. He was indoor sitting. One shock. Chairs shook E.—W. No sound.

Neemuch.—Not felt.

Ujjain.—Mr. G. H. G. Foxwell, Telegraph Master. Time between 5-30 and 6 (guessed). Two shocks with about 20 to 30 seconds' interval. Direction W.—E. or N.W.—S.E. The shock was felt by many in the N. part of the town, causing oscillation of the buildings, displacement and rattling of tiles, glasses and bottles, especially in upper stories.

Hurra District.

Agucha.—Reported by the Resident of Mewar. At sunrise. There was a slight rumbling sound for 1½ minutes.

Mandalgarh.—Reported as above. About 6 A.M. Water in reservoir of fort shaken up several times.

Kumalgarh.—The same authority records the same effects.

Indore State.

Indore.—Meteorological Observer. The shock was noticed by persons in upper rooms in bed. There was a rattling of doors. Time 6-15 A.M., about. Direction E.—W. Duration about ¾ minute.

Samer.—Reported by the Indore Durbar. Time 5-30 A.M. Two shocks, with 5 minutes (*sic*) between. No damage.

Manasa.—Reported by the Indore Durbar. At sunrise. Duration 15 seconds. No damage.

Malwa District.

Rajgarh.—Lalla Bakhat Bahadar, Police Inspector. Lying down indoors. Shock of 2 seconds. There was a to-and-fro movement of chains fitted in doors. No damage.

Narsingarh State.

Narsingarh.—Durga Sahai, Superintendent, Narsingarh State. He was indoors, second story, asleep. Time 6-15 A.M. There were 3 distinct shocks. The bed rocked as if there were an animal under it. Doors shook, punkah moved. He rushed out of doors. No objects were overturned. No cracks or fissures. It was only felt by some in the town. The shock was also said to be felt at Khujner, 30 miles to the W. There was an effect also on some of the dried-up nullahs in the Deccan Trap country, water appearing in them afterwards. No sound.

Panna State.

Panna.—Mr. E. Vredenburg, Deputy Superintendent, Geological Survey of India. He was in bed. Time about 6-5 A.M. by clock and

gun. There were probably several shocks of varying intensity. Direction N.—S. from movements of liquids in glasses, cups and flasks. No sound. It was distinctly felt, very rapid, and there was a rattling in the ceiling and a swinging of the bed. Duration about 1 min. It was not felt by servants and others moving about outside. Felt by many in the city.

Rajgarh District.

Biaora.—Not felt.

Rajgarh.—Postmaster. Time about 5-30. A very slight shock, many people did not feel it at all.

Jhansi District, U. P.

(*Lies within Central India area.*)

Tikamgarh.—H. H. Saramad-i-Rajahai, Bundelkhand Sawai Mahendra, Maharaja Sir Pratap Singh. Time about 6 A.M. He was indoors. No shock was felt, but movements of articles of worship were seen. No sound.

CENTRAL PROVINCES.

Akola District.

Akola.—Not felt.

Amraoti District.

Amraoti.—Not felt.

Bilaspur District.

Pendra Road.—Mr. J. T. Rendall. There was first a rattling of windows and of handles on drawers, also fluttering of a tame parrot. second, oscillation of the ground. Third, rumbling noise from N. for 10 seconds. No damage to bungalow.

Pendra Road.—Kashinath Porshorom Meteorological Observer and Assistant Station Master. In the open air sitting. The shock was hardly felt,

Chanda District.

Chanda.—Not felt.

Chhindwara District.

Seoni.—Not felt.

Ellichpur District.

Ellichpur.—Rama Chandra, Postmaster. Indoors sitting. First he felt an oscillation. Second, pans and beam of parcel scale moved violently. Hanging lamp moved. The shock lasted about 2 minutes. Direction N.E.—S.W. Clock stopped at 6-15. No sound. No damage.

Hoshangabad District.

Itarsi.—Kundan Lall, Mail Contractor. He was indoors sitting. There was first a trem. vibration, second it continued for about 1½ minutes. Direction E.—W. by hanging lamp. No sound.

Pachmari.—Pratap Singh, 1st grade Hospital Assistant and Meteorological Observer. He was indoors. A trem. vibration hardly felt. No sound.

Jubbulpore District.

Jubbulpore.—Not felt.

Katni.—Not felt.

Nagpur District.

Kamptee.—Not felt.

Nagpur.—Not felt.

Narsinghpur District.

Deori Camp (*Beethi village*).—Mr. B. M. Birrell. He was indoors sitting. There was a swaying sensation and trees swayed W.—E.

Gadawara.—Rajendra Nath, Signaller. He was indoors sitting. A distinctly felt to-and-fro movement of his chair which lasted for 1 minute.

Raipur District.

Raipur.—Not felt.

Sambalpur District.

Sambalpur.—Not felt.

Saugor District.

Bina-Etawah.—Debi Prashad. He was indoors sitting. It was distinctly felt. Doors knocked about. No sound.

Saugor (in Civil Lines).—General P. K. Sum Shara Junghavas Bahadur, late Commander-in-Chief, Nepalese Army. He was indoors sitting. Time 6-20 by clock regulated by gun. There were 2 prelim. trem. vibrations and a rattling noise of glass doors, followed by swaying movements lasting 1 minute. Direction E.—W. by hanging lamps and punkahs which swung about 1 ft. each way. No sound.

Saugor.—Shanker Rao. He was indoors lying down. There was a shaking of the sofa which lasted 1 min. "Handies" hanging in the room shook and tinkled. The lamp was shaking on the table. No sound. No damage.

BENGAL.

Balasore District.

Balasore.—Raja Baikunthanath De, Bahadur, of Balasore, Orissa, etc. He was indoors sitting. Time about 7 A.M. (local time). First shock about 4 seconds' duration. Second about 20 minutes afterwards, 1 second's duration. There was, first, a shaking of doors and candelabra, second, 1 or 2 seconds afterwards sounds like a railway train heard. Direction N.W.—S.E. Cracks in arches widened.

Bhagalpur District.

Madhipur.—Not felt.

Birbhum District.

Bolpur.—Not felt.

Suri.—Babu Gopal Chandra Chackerbutty, Hon. Magistrate, Suri. Windows and doors rattled and trembled. Direction W.—E. A rumbling sound underground like that in the 1897 earthquake. Duration 1½ minutes.

Burdwan District.

Burdwan.—Not felt.

Raniganj.—Not felt.

Silarampur.—Not felt.

Ukhara.—Not felt.

Calcutta District.

Calcutta.—Wooma Charn Chatterjee, Telegraph Master, 46, Strand Road. There were distinct prelim. vibrations, but of short duration, followed by 1 slight shock, and then trem. vibrations for a few seconds after. Direction N.—S. Water in tanks much agitated. No sounds.

Calcutta.—Mr. L. L. Fermor, A.R.S.M., F.G.S., Geological Survey of India. Time between 7 and 8 A.M. His bearer and Hem Babu noted the earthquake. The Babu noted water in tank having a N.W.—S.E. movement.

Calcutta.—Mr. A. J. Bolton, M.I.C.E., at 14, Ezra Mansions. He was sitting. Time 6-50. The direction of fans and lamps swinging was E.—W.

Calcutta.—Rev. Father Lafont, S. J., at 10-11, Park St. The electric clock stopped at 6-53 (Calcutta time).

Kalighat (near Calcutta).—Annada Prosad Sircar, Executive Engineer, 2nd Calcutta Division. Water of tank faintly moving from S.—N. and back for about 5 minutes. No sound.

Champaran District.

Baran Chokia.—Bishan Datt, Sub-Postmaster. Time about 8-30 or 9-30 [too late]. Two shocks were felt which lasted 3 minutes.

Betiah.—Gobind Chandra Mukerjee, Sub-Postmaster. Indoors sitting. Time about 6 A.M. There were a few very slight shocks for about 2 seconds

Kisoriah.—Golam Rasool. In the open air sitting. About 5 A.M. by guess. He noticed movements of tank water.

Motihari.—Postmaster. Hardly felt.

Raksal.—Postmaster. Time 7 A.M. Very slight shock lasting 5 minutes. Water overflowed 18 inches (? of tank).

lie.—Hari Das Guin, Sub-Postmaster. Indoors. Time 6-30 A.M. (guessed). It was slightly felt by a feeling as if the brain were whirling for about 20 seconds. Water in tank slightly moved.

Cuttack District.

Cuttack.—Nagendra Nath Mitra, District Engineer. He was indoors sitting. Time 6 A.M. (guessed). There was, first, a slight prelim. tremor noticed by doors moving, and, second, 2 main shocks at intervals of 10 seconds, the second shock being the more intense. Direction N.—S. by doors [not a trustworthy observation]. It was distinctly felt. "If there had been a little more I would probably have tumbled down from chair."

Jobra.—Mrs. M. Marchant. She was sitting indoors. Time about 6-45 A.M. Two shocks. Only very slight to-and-fro movements. There was no interval between the shocks but a difference of direction, 1st, N.—S and afterwards N.W.—S.E. No trem. vibrations before or after. Duration about 1 minute. The shocks were distinctly felt by herself and by friends living some distance away. A glass of water placed on table gave the direction. The servants noticed the tops of mango trees swaying about 40 yards away. [NOTE BY TELEGRAPH MASTER.—"The shock was not felt by others in the station."]

False Point Lighthouse.—Biswanath Singh, Flagman, Government Telegraph Department. He was indoors seated. Time 6-30 A.M. (lighthouse time, which is 26 minutes in advance of Madras time) [this seems too early]. There was 1 shock only which was hardly felt by the flagman where he was seated, but the look-out shouted from above asking whether it was felt below. The flagman then noticed that the lightning conductor above the lighthouse was swaying as if some one were shaking it.

Darbhanga District.

Darbhanga.—Jogin Chander Bannerjee, Hospital Clerk. He was indoors sitting. Time about 6 A.M. (guessed). There were 2 shocks lasting 4 seconds. Hardly felt.

Kamtaul.—Postmaster. Time 6-15 A.M. It lasted 2 minutes. No damage.

Lakeria Serai.—Ishon Chandra Dey, Sub-Postmaster. He was indoors standing. Time 6-10 A.M. by Telegraph Office clock. There was one shock. No trem. vibrations before or after. Oscillations of hanging lamp from N.—S. Water in pool waved gently. No sound.

Naraya.—Postmaster. Felt slightly by some people.

Pandaul.—Mahomed Ali Habib, Sub-Postmaster. He was indoors sitting. Time 6-30. It was slightly felt, weighing scale shook. There were 3 or 4 slight shocks at intervals of 5 or 6 seconds. Duration nearly 1 minute. Movements of water in tank and river. No sound. No damage.

Pusa.—Babu Suresh Chandra Mukerjee. He was indoors standing. Time 6-15 P.M. [probably a slip for A.M.] by watch compared with telegraph clock. There were 4 or 5 shocks felt with intervals of 3 or 4 seconds. It was distinctly felt. Chains of door moved. Sound before the shock like falling of trees and stones.

Rajnagar.—Not felt.

Darjeeling District.

Darjeeling.—Mr. F. E. Möller, of Halcyon House. He was indoors lying down. Time 6-50 A.M by watch. It was hardly felt. Chains of hanging lamp went up and down. Direction E.—W.

Darjeeling.—Mr. J. Stalke, Rischol Tea Estate. He was upstairs on a balcony. Time 6-35 A.M. by watch found to be 2 minutes faster than railway time 2 days after at Darjeeling station. There were 4 distinct tremors at intervals of 20 seconds, each being of equal intensity. Total duration 2 minutes by watch. Direction W.—E. from tea in his cup.

Gaya District.

Gaya.—Not felt.

Hazaribagh District.

Hazaribagh.—Nuthoo Lal, Meteorological Observer. Time between 6-10 and 6-13, Madras time. He was asleep himself during the earth-

quake, but it was reported that E.--W. movements were indicated by lamps suspended from the roof of the Mission Chapel. The rafters creaked. The shock gradually reached a climax and then subsided. The shocks were of 3 minutes' duration.

Hazaribagh.—C. A. E. Kuchhop, Hospital Assistant to the Dublin University Mission. He was in the verandah sitting. Time past 6 A.M. (judged by 6 o'clock prayer service going on at the time in the Mission Chapel). He received 3 or 4 shocks against the wall. Water *lotah* was troubled and also tea in cups. The roof rustled. Direction E.—W. Duration about ½ minute. No damage.

Hugli District.

Chandernagar.—Gobordhone Seal. He was indoors, sitting. Time 6-45 (guessed). Doors moved N.—S.

Chandernagar.—Bhringeswar Srimany, Attorney-at-Law. Tank water moved W.—E. or E.—W. Time about 6-55 to 7-10 (Calcutta time). Possible error 2 minutes either way. Hanging lamps swung.

Rishra.—Babu Hira Lall Banerjee. There was a little shock and movements of water in tanks, and trees.

Serampore.—Not felt.

Tarakeshwar.—Chandra Nath Bose, Sub-Postmaster. Time 6-38-10 (Madras time) by clock daily regulated at 16 hr. by Madras. Water of tank oscillated for at least 6 seconds. Direction W.—E.

Jessore District.

Jessore.—The District Engineer, Jessore [name illegible]. He was indoors. Time 6-30 A.M. (guessed). There were no distinct shocks, only slight tremors. It was hardly felt.

Khulna District.

Khulna.—Hari Das Chatterjee, District Engineer. In an upper storey verandah facing the road. Time 7-5 about by watch and clock. There were 2 slight almost imperceptible shocks with 1 second's interval Duration 2 seconds. Direction N.W.—S.E. by his feelings and by movements of the water in a tank. No sound.

Manbhum District.

Jharia.—Not felt.

Midnapur District.

Midnapur.—Babu Jadu Nath Ghosh, Head Clerk, Executive Engineer's Office. He was in the open air standing. Time about 6 or 6-30 A.M. No shock was felt, but water in a tank moved E.—W. It was also noticed by many other people who recognised the nature of the phenomenon and blew conches.

Monghir District.

Begu Sarai.—Not felt.

Gidhaur.—Srikantha Bhattacharyya, Sub-Postmaster and Signaller. Time 6-17 A.M., Madras time, by clock regulated daily at 16 hrs. There were 1 or 2 distinct tremors continuing for about 2 minutes. The table shook. Window planks and panes moved E.—W. No sound.

Lakhi Sarai.—Not felt.

Monghir.—Mr. C. A. Oldham, Collector. He was indoors sitting. Time 6-12 by railway time, clock and watch. Only one shock felt. Direction N.—S. or N.W.—S.E. by revolving book-case 4 feet high shaking ½ inch and also by lamp.

Monghir.—Gunga Bishoon Pershad, Head Signaller. He was sitting indoors. Time about 6-10. There were 2 distinct shocks. Walls and water began to shake N.—S. No buildings cracked. No sound.

Murshidabad District.

Berhampore.—Mahendra Nath Ray, Meteorological Observer. He was in the open air walking and so not felt, but he was told there was a shock felt by about 1 per cent. of the people. Punkah rope swung W.—E.

Kandi.—Officiating Sub-Postmaster. A slight shock between 6 and 6-30. It was perceptible on the surface of a tank. Direction W.—E.

Patkabarie.—Observer was indoors lying down. Time about 6-30 by guess. Two distinct but slight shocks with 10 seconds' interval. Direction N.—S.

Muzaffarpur District.

Lalganj.—Mr. C. N. Gordon. He was sitting. Time between 6 and 6-30. There was a vibration lasting 16 seconds followed by a shock of 2 minutes' duration. Water was thrown out of tanks. No sound.

Raipur.—Brajanandran Prasad Varman, Zemindar. Time between 6 and 7 A.M. Duration about 3 mins. It was hardly felt.

Sitamarhi.—Postmaster. Time 6-15. Duration 15 secs. 3 or 4 slight shocks. Direction N.—S.

Nadia District.

Nadia.—Dharmi Das Mukerjee, Sub-Postmaster. He was sitting indoors. Time 6-50. One slight shock lasting 2 seconds

Nadia.—Postmaster. Time 6-50 (Calcutta time=6-17 Madras time). Duration 2 seconds.

Palamau District.

Daltonganj.—Not felt.

Japla.—Not felt.

Patna District.

Bankipore.—Mr. J. S. Cohen, Signaller. He was indoors sitting. Time about 6-35 (guessed). Two shocks very slight, first lasting about 15 seconds, then 10 seconds' interval, then second shock lasting about 15 to 20 seconds. Direction N.W.—S.E. No sound.

Bankipore.—Lieutenant-Colonel R. H. Whithwell, I.M.S., Civil Surgeon. He was sitting indoors. Time 6-10, Madras time. There was a sharp tremor accompanied by a slight rumbling noise. Direction N.W.—S.E. No damage.

Bihar.—Hari Das Banerji, Sub-Postmaster. He was sitting indoors. Time 6-15. One shock, very slight. Vibration lasted for 3 seconds. Hanging lamp swung W.—E. No sound.

Dinapur.—Not felt.

Mokameh Ghat.—Mr. C. P. Wardo, Inspector of Works, Bhagalpur Circle. Indoors lying down and sitting up. Time shortly after 6

A number of to-and-fro movements in rapid succession gradually lessening. Direction W.--E. A door half open swayed about ½ inch. No sound.

Shahabad.—Postmaster. Time 6-20. Five shocks, E.—W.

Purnea District.

Purnea.—Capt. J. W. F. Rait, I.M.S. Not felt.

Ranchi District.

Ranchi.—Jatindra Nath Kundu, Clerk, Executive Engineer's Office. Indoors sitting. Time about 6 A.M. (guessed). One slight shock N.—S. or S.—N. Chair moved, ropes swung and water in bath moved. No sound.

Saran District.

Chapra.—Mr. G. R. Ensell. He was indoors sitting at first, afterwards in the verandah standing. Time 6-15 A.M. by telegraph clock at the end of the shock. Three principal shocks of 2 seconds each at intervals of 3 seconds each. Direction S.W.—N.E. There was a tremulous vibration before the shock and a sound like the rumbling of a train gradually increasing. No trem. vibration afterwards. Birds in aviary and trees were frightened. A large tree rocked to and fro although the air was still. Slight cracks in buildings on W. side from N.—S.

Digwara.—Postmaster. Time about 6 A.M. No details.

Gopalganj.—Not felt.

Hathwa.—Not felt.

Jamo Bazar.—Harihar Charan Lal, Sub-Postmaster. He was sitting indoors. Time 7-7 A.M. by telegraph clock. It was a single slight shock of 5 seconds' duration. There were movements of water in tanks and fall of loose articles.

Maharajganj.—Postmaster. A very slight shock lasting about 2 seconds.

Mairwa.—Not felt.

Revelganj.—Postmaster and Sub-Postmaster. Time 6 A.M. One slight shock of 1 second's duration. Direction W.—E. and N.—S.

Siwan.—Not felt.

Sonpur.—Not felt.

Shahabad District.

Arrah.—Mr. G. L. Shaw, Barrister-at-Law. Time about 6 A.M. (guessed). He felt a giddiness which he attributed to the earthquake, but he felt no shock.

Buxar.—Not felt.

Bihia.—Mr. E. Mylin. Others in bed felt a slight shock.

Bihia.—Mr. C. Fox. Time 6-30 about. Only a slight tremor. Direction apparently N.—S. Only felt by a few.

Sonthal Parganas.

Pakur.—Postmaster. Not felt.

24-Parganas District.

Achipur.—Mr. G. C. Mukerji, Telegraph Master. Time 6-55 by office clock. Hardly felt. Water of tank moved S.W.—N.E. and receded about 1 foot.

Bahala.—Not felt.

Budge-Budge.—Not felt.

Canningtown.—Not felt.

Cossipur.—Jagat Durlove Shaw, Sub-Postmaster. Movements of water in tank seen by Babu Ashutosh Mustafi, Money Order Clerk. Direction W.—E.

Diamond Harbour.—Heshab Lall Chatterji, Overseer, District Board. Hardly felt. Direction E.—W. by movements of tank water. Time 5 or 10 minutes before 7 A.M. (guessed).

Hooghly Point.—W. C. Ghosh, Telegraph Master. Time 6-30 almost (local time) by telegraph clock. One shock hardly felt. Tank water moved E.—W. for 2 minutes.

Kidderpore (at 7, Berapuker Road).—Baidyanath Ghosh, Signaller. Time 6-10 A.M. (guessed). One distinct shock, W.—E.

Mud Point.—G. C. Ghosh, Telegraph Master. Time 6-50 local time, telegraph clock = 6-17 Madras time. No shock felt. Water in tanks moved E.—W.

Saugor Island.—Mr. T. W. de Souza, Telegraph Master. Local time 6-50 A.M. = 6-17 Madras time. He was indoors standing. The shock was not felt although Mud Point Telegraph Master drew his attention to it. The barograph which would show any movement from N.E.—S.W. has a distinct upright stroke about 6-15 A.M. while the thermograph which faces N. and would show any tremulous movement E.—W. shows nothing. Hence he concludes the slight shock which did occur passed from N.E.—S.W. between 6-40 and 6. 50 A.M. (local time).

EASTERN BENGAL AND ASSAM.

Whilst many observers from places in this area have sent in earthquake forms stating that no shock was felt at the date and time required for the Kangra earthquake, a number on the other hand have sent in forms giving such discordant times that they only more or less doubtfully can be correlated as the distant effects of that shock. The frequent mention of sounds accompanying the shocks at these places further disposes one to regard them as really local in origin, and having nothing to do with the Kangra quake; for at such a distance it is not likely that any such sounds would have been heard, especially since at corresponding and intervening distances otherwise situated with regard to the epicentre no sounds have been recorded. Accounts have been received as follows :—

Backerganj District.

Barisal.—Syama Charan Chakraverty, Overseer, District Board. Time after 6, and nearing 7. Water in tank (artificial reservoir) rose 7 inches at S.E. and N.W. corners and only 4 inches in the opposite corners. Also the water dashed more prominently on the N. and S. sides than on the E. and W. He concludes that the shock had a direction about N.N.W.—S.S.E. No sound.

Barisal.—Sreecharan Roy, Clerk in Post Office. Time about 6-30 by guess. Tank water moved N.—S. No sound.

Bogra District.

Bogra.—Not felt.

Cachar District.

Cachar (at Daloo Tea Estate).—Mr. A. Rose. He was indoors sitting. There was, first, a creaking of the roof, second, the main shock, and afterwards a quivering motion lasting 1 minute. Direction N.—S. or S.—N. Time shortly after 6 A.M. The factory bell rang at 6 o'clock and the shock was felt about ½ hour afterwards. Sounds were heard the previous evening like dull thunder or heavy train over a bridge. Also heard ½ hour after the shock. A tall flower vase upset pointing N. No cracks, no fissures. *N.B.*—The house is an iron-framed one with columns resting on brick pillars 3 feet below the surface. Consequently the least vibration is felt, but there being no brickwork there was no damage.

Chittagong District.

Banigram.—Lakshmi Kanta Bhattacharjee, Sub-Postmaster. He was standing in the verandah. Time about 7-15 (local time guessed). Movements in tank water from W.—E. There were 2 distinct shocks.

Fatehabad.—Ananda Chandra Dass, Officiating Sub-Postmaster. He was sitting indoors. Time about 5-30 A.M. Movements of water in tank for about 20 minutes from N.—S.

Katirhat.—Sub-Postmaster. No time given. The shock was felt very slightly by the water in tanks and by the swinging of lamps.

Sholashahar.—Munshi Lakir Ali, 3rd clerk in District Engineer's Office. He was sitting outside. Time about 7 A.M. (guessed). Movements of water in tank lasting for 15 minutes was all that was noticed. Direction N.W.—S.E. The water suddenly subsided at one end and rose at the other end of the tank.

Dacca District.

Dacca.—Babu Shashi-Bhusan Mitter, B.C.E., District Engineer. He was out of doors moving. Time about 7 A.M. (local time guessed). The only effect was water in tank moving W.—E.

Narayanganj.—Not felt.

Faridpur District.

Faridpur.—Babu Hari Mohan Mukerjee, Draughtsman, District Engineer's Office. He was in the open air. Time about 8 A.M. by guess. It was distinctly noticed by movement of tank water from S.—N. and also by hanging earthen utensils in kitchen.

Jalpaiguri District.

Jalpaiguri.—Mr. J. E. Armstrong, District Superintendent of Police. He was indoors sitting up in bed. Time about 6-30 by guess. There was one shock or trem. vibration lasting 5 seconds. No sound.

Lakhimpur District.

Halwari.—Devendra Nath Mazumdar, Postmaster. Time about 9-15 [guessed, but is rather late even for a bad guess]. One long shock, S.—N. There was a distinct rumbling noise for some seconds, followed at once by a severe shaking. The noise was very peculiar, coming so distinctly before the actual shock. No damage.

Lakhimpur.—Kamad Nath Bhattacherjee, Postmaster. Time about 8 A.M. [guessed, is rather late]. A fairly distinct shock. Direction W.—E. from mangoe tree movement. Sound at the beginning. No damage.

Lakhimpur.—Mr. J. Paul, American Baptist Mission. Time 7-30 (approximately) [if this is local time it is not far out]. Direction N.—S. from movements of water under bridge.

Mymensingh District.

Mymensingh.—K. Nag, Telegraph Master. Only movements of tank water perceived.

Sibsagar District.

Sibsagar.—Abinas Chandra Chatterjee, Meteorological Observer. Time 9-28 A.M. [this is much too late]. He gives sound records and other numerous details.

Sylhet District.

Chatali.—Mr. C. J. Jackson, Jagcherra Tea Estate. Time 1 o'clock [A.M. or P.M. not stated]. A slight shock. Hanging lamp swung.

Chhatak.—Sasi Mohan Chaudhury, Postmaster. Time about 2 P.M. Direction S.E.—N.W. No sound. One shock, hardly felt.

Patharkandi.—Ram Saran De. Time about 7, Madras time [it is of course possible that the observer was ¾ hour out]. One shock, hardly felt. Direction N.—S. No sound.

Charahamna.—Rajani Chandra Datta, Head Master (School). Time 5-30 [too early]. There were movements of water S.W.—N.E.

Sylhet.—Nagendra Chandra Bose, Telegraph Master. Time 12-48 Madras time. Three or 4 smart shocks felt in quick succession at intervals of about 2 seconds. Distinctly felt. No sound.

Tipperah District.

Chandpur.— ...... Chandra De. Between 7 and 8 A.M. Only movements of water seen.

Chatelpur.—Sasi Bhusan Ghose, Sub-Postmaster. One shock hardly felt. Water of tank undulating. Time between 6 and 7.

Comilla.—District Engineer. Time 6-30 A.M. Water of tank oscillated violently.

Sarail.—Girish Chandra Ghosh, Sub-Postmaster. Time between 6 and 7 A.M. One shock, water of tank undulating.

NEPAL.

Kathmandu.—Major P. Canawd, Superintendent, Nepal Observatory. Time 6-6. The shock was slight. [No further details given.]

MADRAS.

There is only one account of the earthquake being felt in the Madras Presidency, and about this there is some doubt (see page 350). At Kodaikanal the shock was registered on the Milne seismograph. But the shock was not sensibly felt (see page 290).

BURMA.

There is no reliable evidence for the earthquake having been felt in Burma. From the following places we have received positive statements to the effect that it was not so felt:—Akyab, Bhamo, Mandalay, Maymyo, Minbu. On the other hand from Monywa, Mr. P. T. McCarthy, Superintendent, Meteorological Observatory, has recorded "slight tremors for a few seconds" but without giving any details. Similarly from Tiloya in the Southern Shan States, Mr. J. O. B. Donaghey, Extra Assistant Superintendent, Survey of India, mentions distinct tremors lasting 3 seconds with a deep rumbling sound but occurring at 4 P.M. on the 22nd of March. This was therefore a local shock having nothing to do with the earthquake of the 4th April.

An interesting account, however, comes from Thedaw in the Meiktila District, Upper Burma, where Mr. R. Berrill, Public Works Department, noticed between 7 and 8 A.M. on the day of the big earthquake irregular movements of the bubble in his level tubes (see also page 328).

LIST OF CONTRIBUTORS TO THE EARTHQUAKE FORMS.

A

Abdul Aziz, Baramulla, Kashmir: Abdul Aziz, Gupis, Kashmir: Abdul Aziz, Nalapani, Dehra Dun: Abdul Aziz Khan, Dinapur: Abdul Jalil, Dehra Dun Abdul Kadir, Bharatpur, Rajputana: Abdul Majid, K. M., Delhi: Abdul Mohid, M., Manglaur, Saharanpur: Abdul Rahman, Amballa City, Amballa: Abdul Rahman Khan, Alwar, Rajputana: Abdul Rasid Khan, Sambhar, Rajputana: Abdul Wazir, Machhlishahr, Jaunpur: Ahsan Ali Munshi, Barmer, Jodhpur: Adie, J. R., Ferozepore: Ahmed Ali Khan, Budaun: Ahmed Hassan Khan, Kohala, Rawal Pindi: Ahmed Hassan Niaz, Meerut: Ahmad Said Khan, Thana Ghazi, Alwar: Akbar Shah, Ali, Sadda, Kohat: Allahdin, M., Charsadda, Peshawar: Allen, J., Naini Tal: Allen, J. M., Naini Tal: Ali Mahomed, Raya, Amritsar: Alimuddin, Ratangarh, Bikaner: Alimuddin, Agra: Allum, E. W., Landour, Dehra Dun: Amarchand, Munshi, Boodhgam, Kashmir: Amar Nath, Darazanda, Dera Ismail Khan: Amar Nath, Baffa, Hazara: Amba Datt Joshi, Jealikote, Naini Tal: Amba Lall, Pandit, Haldwani, Naini Tal: Amba Lall Roshod, Sadra, Mahi Kantha: Amba Prasad, Dehra Dun: Ambiya Charan, Kadaura, Baoni: Anesbury, S. C., Roorkee: Amichund Ambalal Modi, Ahmedabad: Amir Ali, Mahomed, Haripur, Hazara: Amir Chand, Warshand, Kohat: Annada Chandra Dass, Fatehabad, Chittagong: Anderson, A.,

Dehra Dun: Anonymous, Sangrur, Jhind: Ansell, R. C., Jullunder: Armstrong, J. E., Jalpaiguri: Arthen, A. B., Mundir, Karnal: Ashburn, A. R., Simla: Ashford, J., Amritsar: Ashly, R. J., Dinapore, Patna: Asvini Kumar Naha, Bagribari, Dhubri: Atkinson, R. P., Dhakauli; Meerut: Atkinson, G. W. E., Amritsar: Aulad Hosein, S., Dehra Dun: Auruam Singh, Lachmangarh, Jaipur: Azizdinashai, Piristan Fort, Kashmir: Azizuddin, Delhi: Azizullah, Ramnagar, Gujranwala: Azmat Ali, Kalpi, Orai.

B

Badir Prasad, Brindaban, Muttra: Badri Narayan Misra, Farrukhabad, Unite Provinces: Badri Nath, B., Nahan, Amballa: Badri Prasada, Sikandra Rao, Aligarh: Bhagat Singh, Mainpuri: Baikuntha Nath De, Raja, Balasore: Bairoti Lal, Hardoi: Paksh, Alla, Jagradum, Ludhiana: Baksh, Amir, Khetri, Jaipur: Bala Koul, Titwal, Kashmir: Balfour, J. H., Choya Saidan Sha, Jhelum: Balmokand, Munshi, Alwar, Rajputana: Balmukund Kapur, Narnaul, Patiala: Balsarup, B., Mianwali: Banerjee, Haridas, Bihar, Patna: Banerjee, Hira Lall, Rishra: Banerjee, Jogin Chander, Darbhanga: Banerjee, K., Tarkhani, Lyallpur: Bankey Lal, Kotputli, Jaipur: Bannerman, A. D., Kotah: Barlow, G. T., Band: Barton, G., Kohat: Basheshar Dass, Jandiala, Amritsar: Basheshar Nath, Pandit, Unao City, United Provinces: Bosu, Sachindra Nath, Bankipur: Battacharjee, Kumud Nath, Lakhimpur: Battacharjee, Lukshmi Kanta, Banigram, Chittagong: Battacharya, Srikanta, Gidhaur: Beaford, W., Landour, Dehra Dun: Behari Lal Kabra, Poonch, Kashmir: Bellasis, E. S., Band Karnai, Dera Ismail Khan: Beni Prasad, Pandit, Mainpuri: Bennett, W. E. T., Sialkot: Berril, R., Thedaw, Burma: Bhagat Ram, Tank, Dera Ismail Khan: Bhagawat Ram Sanbay, Sibna, Ludhiana: Bhagat, Sudaman, Kulachi, Dera Ismail Khan: Bhagawat Dial, Tilhar Shajahanpur: Bhagwan Dass, A., Katni: Bhagwati Prasada Varma, Kangra Canal Resthouse, Lyallpur: Bhagwal Pershad, Digstate, Rajputana: Bhagwan Singh, Mardan, Peshawar: Bhai Sultan Singh, Rasalpur, Ferozepore: Bhairah, Dutt Joshi, Pandit, Poonch, Kashmir Bhanushankar Itcharam, J., Gandevi, Baroda: Bhandoo Digambar Rangari, Faizpur, Khandwa: Bhi Ran Lal, Sahinspur, Dehra Dun: Bhoja Gawar, Kundala, Ajmere: Bhola Datt Tewari, Pauri, Garhwal: Bhola Nath Pundri, Karnal: Birbal, Dehra Dun: Birbal, Pandit, Kapurthala: Birrell, B. M., Beethi, Narsingpur: Bishambhar Nath, Chunar, Mirzapur: Bishambar Nath, Dera Ghazi Khan: Bishambar Nath, Islam Canal, Multan: Bishambar Sarap, Jhojjar, Rohtak: Bishan Das, Hoshiarpur: Bishan Dass Dutt, Hissar: Biswanath Singh, False Point, Cuttack: Bisheswar Dyal, Muzaffarnagar: Blong, M. J., Mussoorie: Blood, Sir B., Rawal Pindi: Boaz, Gorakpur: Bolton, A. J., Calcutta: Bonnaud, R. L., Ludhiana: Boronha, L. J., Hyderabad, Sind: Bosanquet, O. V., Samer Alampur, Indore: Bose, Chandra Nath, Tarakeshwar: Bose, Nagendra Chandra, Sylhet: Bostron Werner, Meerut, Aligarh: Bons, H. J., Gopalpur, Madras: Bowder, A. G., Landour, Mussoorie: Brajanandan Prasad Varman, Raipur, Muzaffarpur: Bran

dreth, S., Patiala: Brij Jiwanlal Sarma, Pandit, Ajmere: Brij Lall, Shahabad, Karnal: Bristoe, F., Mussoorie: Brown Grey, Lahore: Bryson, A. C., Fyzabad: Buchanan, W. E., Simla: Budhu Ram, Shajahanpur City: Budin, S. S. N., Las Bela, Baluchistan: Brij Bash Lal, Okara, Montgomery: Buksh, Maula, Fazilka, Ferozepore: Buksh, Nabi, Daraban, Dera Ismail Khan: Buksh, Pir, Jullundar: Buksh, Sheik Allah, Miranshah, Tochi: Buksh, Suraj Lala, Kathumbar, Alwar: Burn, I. M., Saharanpur: Burrard, Lieutenant-Colonel S. G., Dehra Dun: Burrow, C. J., Srinagar: Burt, C. H. S., Ghazipur: Bux, Mahomed, Chitral Fort.

C

Cairncross, Arthur, Etawah: Cameron, Donald, Dehra Dun: Carim Bux, Mansehra, Hazara: Carne, F. W., Lyallpur: Carr, W. P., Peshawar: Carroll, P. M., Malakand: Carroll, I. M. S., Basti, United Provinces: Cassen, H. A., Kharr, Dera Ghazi Khan: Castello, R. J., Mount Abu, Rajputana: Chainsukh, Kundhla, Muzaffarnagar: Chakrabarty, Nobin Chand, Katirhat, Chittagong: Chakravarty, Syama Charan, Backergange: Chakerbutty, Gopal Chandra, Suri, Birbhum: Chambers, N. A. R., Mussoorie: Champa Lal, Udaipur: Chandra, Upendra Ch., Revelganj, Saran: Chanan Ram, Delhi: Chandu Lal Sitaram, Bakshi, Jammu: Chapman, A., Mussoorie: Chappel, H. E., Amballa: Charan Singh, Lyallpur: Charles, J. R. E., Roorkee: Charu Dass, Sambria, Sialkot: Chatterjee, Abinas Chandra, Sibsagar: Chatterjee, Hari Das, Khulna: Chatterjee, Hari Kumar, Canning Town, 24-Parganas: Chatterjee, Keshab Lall, Diamond Harbour, 24-Parganas: Chatterjee, K. N., Allahabad: Chatterjee, K. R., Basti, United Provinces: Chatterjee, N. C., Budge Budge, 24-Parganas: Chatterjee, S. N., Kanaud, Patiala: Chatterjee, Wooma Charn, Howrah: Chatrapati, Rao Bahadur, Alipura, Bundelkund: Chatur, Behari Lal, Dehra Dun: Chaubay, Mewa Ram, Unao, United Provinces: Chestney, H. W. P., Asabutai, Ferozepore: Chhajju Singh, Fategarh, United Provinces: Chhajj Ram, Dhanaura, Karnal: Chiman Lall, Gurdaspur: Chimon Lal, Agra: Chiraup Dass, Nurmahal, Jullundar: Choti Lal, Lala, Banda: Choty Lal, Shahabad, Hardoi: Choudhuri, Taran Krishna, Raneebazar, Rajshahye: Chowdhury, Mokhada Prosad, Burdwan: Chowdhury, Parshnath Roy, Jessore: Chowdhury, Sasi Mohan, Chatak, Sylhet: Claxton, G. E., Weslypore, Kheri: Claxton, P., Gonda: Singhwala, Lahore: Clayton, F., Tarai, Naini Tal: Clifford, W. H., Mirzapur: Cline, A. E., Didwana, Marwar: Cohen, J. S., Bankipur: Coleman, A., Chakdara: Collins, B. B., Nalapani, Dehra Dun: Collins, T. E., Phillour, Jullundar: Collins, W. J., Fategarh, United Provinces: Colyer, C. A., Aurangabad, Gujrat: Coode, F. T., Naini Tal: Coombs, L. H., Garais, Kashmir: Coridon, E. H., Tando Masti Khan, Sind: Courthope, Edward A., Dehra Dun: Coverdale, A. L., Islamabad, Kashmir: Crawford, E. L., Amritsar: Crookshank, A., Amballa: Crosthwait, H. L., Captain, Cawnpore: Cuerden, C., Peshawar: Cullen, Captain W., Landour, Dehra Dun: Curtis, J. S., Muzafferpore,

D

Daliya Ram Ramchand, Deesa: Dalu Sabay, Bari, Rhotak: Damodar Dass, Deoband, Saharanpur: Dari Lall Tripathi, Bahraich, United Provinces: Darby Bernard, Hardwar, Saharanpur: Datta, D. N. P., Hoshiarpur, Kangra: Datta, Rajani Chandra Charahamma, Sylhet: Daulat Ram, Lala, Kolthal, Karnal: Daulat Ram, Idak, Tochi: Daulat Singh, Mehta, Kishengarh: David, W. J., Mian Mir: Davies, J. F. C., Gorakpur: Dayashai Bhavanishanker, Nadiad, Kaira: D'Cruz, S., Simla: Deans, H., Astor, Kashmir: Deas, Captain, Sambrial, Sialkot: Debenham, C., Delhi: Dehi Sohai, Sultanpur, Oudh: Dessu Ram, Sirohi, Rajputana De Silva, F. A., Raniganj: Deverell, Hilda, Mrs., Lahore: Devinditta, Jammu: Dewan Ali, Shaik, Ludhiana: Deyi, A. L., Bankipur: Dey, Ishan Chandra, Laheriasarai, Durbhanga: Dhanpat Rai, Astor, Kashmir: Dharani Dhar Das, Bijnaur: Dhera Mall, Dhariwall, Gurdaspur: Dhody, M. S., Kathyala, Lahore: Dhran Chand, Hangu, Kohat: Dhuli Chand, Bhim Tal, Naini Tal: Diwavali, Ludhiana: Dinga Singh, Mona, Shahpur: Diwan Chand, Bikaner, Rajputana: Dixon, F. G., Lahore: Dixon, T. I., Dhaipai, Ferozpore: D'Morris, Albert, Cawnpore: Dobbs, H., Nimla Bagh, Jallalabad: Daderet, W., Ahmedabad: Donaghey, J. O. B., Tiloya, S. Shan States: Donald Macfarlane, Simla: Donald, W. A., Simla: Donne, Bandipur, Kashmir: Douglas, M. W., Simla: Doulat Ram, Aligarh: Dowarllapershad, Uri, Kashmir: Drake, A. J. A., Nalapani, Dehra Dun: Drummond, A. B., Tonk, Rajputana: Duear Lal, Hatteras, Aligarh: Duli Chand, Pandit, Bansur, Alwar: Dundee, W. J. D., Peshawar: Dunning, C. W., Ranikhet, Almora: Durbar, Indore, Indore State: Durbar, Mewar, Mewar State: Durga Prasad Shankadhar, Bareilly: Durga Sahai, Narsingarh: Dutt, Bishan, Barahchouki, Champaran: Dya Ram, Churu, Bikaner: Dya Ram, Etawah.

E

Eleazar, W. A., Burdwan: Ellis, B. J., Fatehpore, United Provinces: Eimslie, Nasirabad, Ajmer: Ensell, G. R., Chapra, Saran: Ernest, Melui, Bihia, Shahabad: Evans, J. S. L., Mussoorie.

F

Faddy, C. S., Ilampur, Multan: Farrant, J. T., Jhelum: Farren, D., Patiala: Fateh Chand, L., Dhakal, Patiala: Fateh Shah Khan, Ferozpore: Fazl Elahi Gujranwala: Fenton, M. W., Jullundar: Fermor, L. L., Calcutta: Ferrar, M. L., Dera Ghazi Khan: Fidelis, G., Bharatpur, Rajputana: Fitzgerald, F. A., Baijnath, Kangra: Fleming, A. M., Chanda: Foord, A. W., Jubbulpore: Foster, H., Dalhousie, Gurdaspur: Fox, J., Bihia, Shahabad: Foxwell, G. H. G., Ujjain: Francis, W. C. C., Deoria, Gorakpur.

G

Gabriel, F. E., Srinagar : Gajadhar Prasad, Bijawar, Bundelkhand : Gale, A. B. Lucknow : Ganaisha, Bijawar, Bundelkhand : Ganda Mall, Skardu, Kashmir : Ganeshi Lal, Lala, Lachhmangarh, Alwar : Ganesh Prasad, Shukla, Etah Ganesh Rai, Muzaffarnagar ; Ganga Ram, Cherat, Peshawar : Ganpat Rai, Samundri ·Lyallpur : Garantha Mall, Landikotal, Peshawar : Gardner, A., Drang, Kangra : Gardner, W. H., Darjeeling : Gariba, B. B., Ahmednagar : Garrett, Captain C. F., Alwar, Rajputana : Gentry, G., Khanki, Gujranwala : Ghasi Ram Varma, Garhmuktesar, Meerut : Ghomgusa Hussain, Mardan, Peshawar : Ghose, Sasi Bhusan, Chatalpur, Tipperah : Ghosh, Baidyanath, Kidderpore, Calcutta : Ghosh, Jadu Nath, Midnapore : Ghosh, G. C., Mud Point, 24-Parganas : Ghosh, Girish Chandra, Sarail, Tipperah : Ghosh, W. C., Hooghly Point, 24-Parganas : Ghulam Hassain, Tank, Dera Ismail Khan : Gibb, A. S., Wan, Shahpur : Gibson, A. T., Lahore : Gill, Joseph H., Bijnour : Gilmon, J. N., Ludhiana : Gilmore, J., Bapti River, Gorakhpur : Girdhar Lal, Rajguru : Patan, Surat : Girdhari Lal, Boya, Bannu Girdhari Lall, Sopor, Kashmir : Glass, E. L., Kot Naja, Shahpur . Gobardhone Seal, Chandernagore : Gobind Prasad, Childyal, P., Srinagar, Garhwal : Godfrey, W. R., Meerut : Godwin, J., Jammu : Gograjmal, Sujangarh, Bikaner : Golam Rasool, Kisoriah, Chapmaran : Gompertz, J. F. W., Fyzabad : Goodman, W. J., Landour, Dehra Dun : Gopal Puncharam, Nawalgarh, Jaipur : Gordon, C. N., Lalagunj, Murshidabad : Gorton, A. H., Jaipur : Goument, C. E., Amballa : Goverdhan Dass, Cambellpore : Govind Balwant Joshi, Dehra Dun : Govinda Mall, B., Jhelum : Govindasawmy Pillai, Mandalay, Burma : Gowhurst, D., Abbottabad, Hazara : Graham, A. A., Nalapani, Dehra Dun : Grant, F. H., Nalapani, Dehra Dun : Greene, A., Lahore : Gregory, S. H., Fyzabad : Grover, W., Dargai : Gujar Mall, Hissar : Gulab Rai Varma, Ramgarh Jaipur : Gulabsingh, Hazrao, Rawalpindi : Gulam Nabi, Taunsa, Dera Ghazi Khan : Gulsbury, S. L. Bruce, Meerut Gonga Bishoon Prasad, Monghyr : Gurdit Singh, Kalka, Amballa : Gurh Ras, Gujrat : Gurdas Singh, B., Oghi, Hazara : Guru Prasada, Bhatnagar, Bulandshahr, United Provinces : Guru Datta, Kotah.

H

Habibullah, Kalabagh, Mianwali : Habibul Rahman Khan, Drosh, Chitral : Hajee Mohamed, Jagadhri, Amballa : Hallowes, F. S., Mussoorie : Hamedullah Khan, M., Gujrat : Hampden Hobart, A. G., Dehra Dun : Hanson, R. C., Nalapani, Dehra Dun : Hanuman Singh, Amraha, Moradabad : Hardwar Nath, Mainpuri : Hargian Singh, Sikandrabad, United Provinces : Hardial, Pathankot, Gurdaspur : Hardy, W. K., Attock : Hari Dass Guin, Segowlia, Motihari : Haridut Tewari, Bunji, Kashmir : Harihar Charan Lal, Jamabazar, Saran : Haril-Syedh, I., Kadi : Hari Mall, B., Kalka, Amballa : Harkness Bruce, W., Dehra Dun : Harman, T., Landour, Dehra Dun : Har Pershad, Khatauli, Muzaffarnagar

Hari Ram Settu, Dras, Kashmir: **Harrington, A. G.**, Nalapani, Dehra Dun: **Harrison, A. G.**, Srinagar: **Harsahai Lall Varma**, Morena, Gwalior State: **Harvey, G. B.**, Multan: **Hashmat Ullah Khan**, Muzafferabad, Kashmir: **Hazarila Sharma, Pandit**, Sajat, Rajputana: **Heard, E. S.**, Amballa: **Hem Chand Lal**, Dehra Dun: **Hem Raj**, Kairana, Muzaffernagar: **Hennessey, C. J.**, Ludhiana: **Hennessy, W. C.**, Amritsar: **Hesari Lall**, Bhatinda, Patiala: **Hill, Edgar**, Partabgarh: **Hills, E.**, Patkabari, Murshidabad: **Hilton, E. F.**, Orai, Jalam: **Hilton, G. J.**, Jullundar: **Hindly, O. A.**, Lyallpur: **Hiranand**, Miranshah, Tochi: **Hira Nand**, Shahpur: **Hira Lal**, Sardhana, Meerut: **Hira Lal**, Rohtak: **Hira Lal Varma**, Phagwara, Jullundar: **Hira Singh**, Sirsa, Hissar: **Hirdey Ram**, Nokodar, Jullundar: **Hira Khan**, Khera, Budaun: **Hogan, W. J.**, Banda: **Holford, C. H.**, Pachbudra, Jodhpur: **Holley, G. H.**, Rawalpindi: **Hope, C.**, Raiwala, Dehra Dun: **Hope, Miss**, Mussoorie: **Horst, W. C.**, Mussoorie: **Housedon, W. P.**, Naini Tal: **Hughes, B. R.**, Nalapani, Dehra Dun: **Human, W. H.**, Naini Tal.

I

Imam Din, Mian Mir: **Imamuddin, Doctor**, Parachinar, Kurram Valley: **Imamuddin, C. Qazi**, Saiyad, Ajmer: **Ishan Chandra Dev**, Dehra Dun: **Ishwar Das**, Sonemarg, Kashmir: **Ives, H. W. M.**, Wan, Shahpur.

J

Jackson, J. C., Chatali, Sylhet: **Jackson, J. F.**, Lucknow: **Jacob, S. H.**, Jodhpur: **Jagadambalal**, Agra: **Jagat Narain**, Etah, United Provinces: **Jagan Nath Dutt**, Amballa City, Amballa: **Jagan Nath**, Fatehjang, Attock: **Jagannath Parshad**, Sutna: **Jagtap, G. C.**, Baran, Kotah: **Jagat Singh**, Landikotal, Peshawar: **Jaint Prasad**, Kumreya, Kalkankar, Partabgarh: **Jallaluddin, Mirza**, Handwara, Kashmir: **James, H.**, Chakrata, Dehra Dun: **Jamna Dass**, Sahgal, Kartarpur, Jullundar: **Janki Prasad, Lala**, Gobindgarh, Alwar: **Jasbo, G.**, Naini Tal: **Jaspat Rai**, Lahore: **Jatindranath Kundu**, Ranchi: **Jawaharlal**, Kalanaur, Rohtak: **Jeewan Dass**, Rawal Pindi: **Jeffries, E. H.**, Hafizabad, Gujranwala: **Jhunnilal**, Najibabad, Bijnour: **Jogindra Nath Murkerjee**, Benares: **Johnson, W. H.**, Amballa: **Johnston, A. H.**, Amritsar: **Jonson, V. T.**, Lahore: **Joti Prasad, L.**, Gujranwala: **Jugal Kulinae**, Hardoi.

K

Kali Charan, Gonda, Oudh: **Kalidas Mitra**, Benares: **Kanhiya Lal**, Indore: **Kanthack, F. E.**, Amritsar: **Karam Chand**, Palwal, Gurdaspur: **Karm Narain Kapur**, Chiniot Road, Lyallpur: **Karam Singh**, Depalpur, Montgomery: **Kartar Singh**, Dehra Dun: **Kashinath Vittal, Lala**, Kekri, Ajmer: **Kashi Pershad**, Tret, Rawal Pindi: **Kanshi Ram Kapur**, Mantar, Tehri-Garhwal: **Kanshi Singh**, Shankargarh, Peshawar: **Kavanagh**, Hope, Hardwar, Saharanpur: **Kay, Daria**, Murree:

Kehar Singh, Gilgit, Kashmir: Keatinge, G. A., Mussoorie: Kelly, W. M., Dehra Dun: Kennedy, R. G., Simla: Kennegy, J. F., Sialkot: Kettlewell, H. W., Landour, Dehra Dun: Kifayat Ali, Mir, Rajgarh, Alwar: Kilkelly, Mount Abu, Rajputana: Kilman, C., Minimarg, Kashmir: Kingi, L., Mussoorie: Kinlock, W. A., Bilaspur, Central Provinces: Kirkpatrick, E., Bannu: Kirpa Ram, Fort Lockhart, Kohat: Kirpa Ram, Sonepat, Delhi: Kirwar, R. M., Lucknow: Kishanchand, B., Raewind, Lahore: Kishori Lal, Bharatpur, Rajputana: Kitchin, B., Ranikhet, Almora: Kitching, G., Etawah: Knowles, J. K., Meerut: Kazi Ziauddin, Bijnour: Kripa Ram, Pilibhit, United Provinces: Kishnarao, Jhunjhnu, Jaipur: Kuchchhap, C. A. E., Hazaribagh: Kulan, E. J., Mussoorie: Kula Nand, Pandit, Saharanpur: Kunar, A. Chunder, Sitapur, Oudh: Kundan Lall, Itarsi: Kundan Mal, Asan, Ajmere: Kunjabihari Gomaun, Bari, Dholpur, Rajputana: Kunwar Hem Singh, Barmer, Jodhpur.

Lachliman, Khushab, Shahpur: Lacki Ali, Munshi, Sholashaban, Chittagong: Lafont, Rev. F. E., Calcutta: Lahua Singh, Sangla, Gujranwala: Lakhpat Ray, Muttra: Lakhshmi Chand, Khama, Ludhiana: Lakshmi Ram Pandya, Agra: Lala Bag Nath, Jaisalmer, Rajputana: Lala Bakhat Bahadur, Bisra, Rajgarh: Lall, C. B., Dehra Dun: Lalubhai Desai, Vadnagar, Ahmedabad: Laughlin, F. J., Bareilly: Lawrie, G. C., Gujranwala: Lavelle, D. J., Delhi: Leager, Geo., Bareilly, Rohilkhand: Leake, H., Saharanpur: Leventon, Arthur, Silchar, Assam: Lucas, F. J., Lahore: Lucas, T., Lyallpur: Lumsden, P. I., Kotah: Lyon, H. A. R., Mayo-mines, Jhelum: Lyon, W., Sambhar, Rajputana.

M

Maclagan, R. S., Simla: McCarthy, P. A., Monywa, Burma: McConaghey, J., Lahore: Mackinnon, P. W., Mussoorie: Mackinnon, V. A., Mussoorie: Madanlal, Tonk, Rajputana: Maclean, A. H., Palampur, Kangra: Maether, H. M., Lansdowne, Garhwal: Maflin, G. W., Ludhiana: Magbul Elahi, Bhatinda, Patiala: Magratt, H. A., Kohat: Mahabir Prasad, Sipri, Jhansi: Mahadeva Mudalia, Madras: Nalapani, Dehra Dun: Mahamed Ramzan, Faridkote, Ferozepore: Mahamed Akbar Khan, Muktesar, Naini Tal: Mahbubab, Adampur, Jullundar: Mala Pershad, Dholpur: Mangal Singh, Garanthi, B., Jamrud, Peshawar: Manna Lal, Chaoni, Jhalrapatan: Marchant, Mrs. M., Jobra, Cuttack: Marshall, W. A., Azamgarh, United Provinces: Mart, H. B., Rev. Leh, Zadek, Kashmir: Martin, C., Bhamo, Burma: Martin, J. N., Quetta: Martin, W. F., Sitapur, Oudh: Mason, W. B. V., Bareilly: Mass, B. H., Simla: Mathews, S., Lucknow: Mathews, R. J., Fyzabad: Mathura Prasad Bhola, Hardwar, United Provinces: Mattison, Ch., Rev., Fatehpur: Maya Dass, Rawal Pindi: Mayer, C. F., Bhadarwar, Jammoo: Mazumdar, N. R., Dehra Dun: Mazumdar, Devendra Nath, Hulmari, Lakhipur: Megh Rass, Dareeba, Delhi: Megha, Baiar, Ajmere: Messmore, J. H., Pauri, Garhwal: Mhal Chund, Pegan

Chauki, Karnal: Middleton, J., Sargodha, Shahpur: Mihal Singh, Bhiwani, Hissar: Mill, W. H., Lyallpur: Miller, C. H. A., Sialkot: Miller, J., Chakdara: Miller, H. E., Hamirpur: Misra, G. P., Bhilsa, Gwalior State: Mitra, A., Srinagar: Mitra, Ishan Tosh, Beawar, Ajmere: Mitra, Nagendra Nath, Cuttack: Mitter, Hari Das, Serampore: Mitter, Sashi Bhushan, Dacca: Mohamed Abdullah, Gilgit, Kashmir: Mohamed Ali, Habib, Syed, Pandaul, Darbhanga: Mohamed Ali, Shajahanpur City: Mohamed Hussain, Dehra Dun: Mohamed Ibrahim Khan, Partabgarh: Mohamed Nasib, Khiderwala, Lyallpur: Moller, F. A., Darjeeling: Montgomery, A. P., Lyallpur: Mool Chand, Sirohi, Rajputana: Mool Chand, Jhang: Moolchand Gaur, Sardarshah, Bikaner: Moos, N. A. F., Bombay: Moseley, R. K., Kheri, Oudh: Moses, G. C., Narayanganj: Motilall, Gorakhpur: Moti Ram, Dehra Dun: Mualitor Ahmed, Tarn Taran, Amritsar: Mukerjee, B. K., Ballia United Provinces: Mukerjee, Dharma Das, Nadia: Mukerjee, Hari Mohan, Faridpur: Mukherjee, G. C., Achipur, 24-Parganas: Mukerjee, Sures Chandra, Pusa: Mukerjee, Ambuj Nath, Aligarh: Mukerjee, Govind Chandra, Bettia, Champaran: Mokund Singh, Westridge, Rawal Pindi: Mukundananda Acharya, Dehra Dun: Muldhu Ram, Lahore: Mullin, E. J., Kasauli, Sirhind: Mul, Rajpuri, Baijnath, Kangra: Mumtaz Hossain, Kadaura, Orai: Munro, R. A., Rawal Pindi: Murli Dhar, Sikhohabad, Mainpuri: hy, J. E., Moradabad: Murphy, A., Gujranwala.

N

Nag, K., Mymensingh: Nanadati, A., Byramji, Surat: Nanavatty, B. H., Sura: Nand Lal, Dehra Dun: Nandlal Das, Derby, Cachar: Nand Krishna, Lala, Kishengarh: Nannid Rai, Lala, Bahror, Alwar: Nanuram Pandit, Sambha, Rajputana: Narain Dass, Multan: Narain Krishna, Chineij, Mandawa, Jaipur: Narain Sevah Bypai, Banda, United Provinces: Narain Bihari, Lala, Mandava, Alwar: Narain Singh, B., Amritsar: Narbada Prasad Bhurgava, Pandit, Jodhpur: Nathan Lal, Delhi: Nathan Khan, M., Gwalior Residency, Jhansi: Nathu Lal Pandit, Jodhpur: Nathu Mall, Bara Banki, United Provinces: Nathu Narain, Jaipur: Nathu Ram, Loharu, Hissar: Neve, E. E. F., Srinagar: Newal Kishore, Baraut, Meerut: Newton, M. H., Jalalpur Jattan, Gujrat: Niblett, R. H., Mussoorie: Nost, Arthur, Khost, Baluchistan: Nowrojee, Khujoeema, Nadir, Dharamsala: Nuthoo Lall, Hazaribagh.

O

O'Connor, C., Cherat, Peshawar: Ohmkar Prasad, Chaprauli, Meerut: Okhil Chandra De, Chandpur, Tipperah: Oldham, C. A., Monghyr: Ollenbach, O. C., Dehra Dun: Oodoy Ram, Nowgong: Orchard, C. H. F., Kalabagh, Mianwali Osborn, W., Bajaura, Kangra: Owen, Percy, Dehra Dun: Oxley, J. C. S., Seoni.

P

Palamal, Dera Ismail Khan: Palamull, Pindigheb, Attock: Panday, R. G., Akola: Pandit Lakshmi Shanker, Bulandshahr, United Provinces: Pannalal Sharma, Surajgarh, Jaipur: Puranjape, S. G., Khandwa: Pargiter, E. H., Khanki, Gujranwala: Parker, P., Deodhur, Amballa: Parkes, B., Nagpur: Parsharam, Kashinath, Pendra Road: Paterson, Mapletoft, Bharatpur, Rajputana: Partridge, W. R., Sitapur, Oudh: Paul, Joseph, Lakhimpur: Paul, P. W., Jaipur: Pears, E.. Miranshah, Tochi: Peile, H. D., Raipur: Pennel, Mrs. E. F., Bannu: Pereira, J. C., Gauhati: Pereira, J. F., Amritsar: Perkins, Alfred, Murree: Peychand Gupkar, Kashmir: Phillips, P. P., Roorkee: Pitambar Dutt, Barkut, Dehra Dun: Place, F. E., Kotla, Ferozabad: Plomer, F. A., Meerut: Pope, Margaret Emily, Miss, Rurki: Poundarik, Pandit, Chatra: Dattji, Shahpura, Mewar: Powell, C. E., Saharanpur: Prashad, Debi, Bina: Pratap Singh, Pachmarhi: Pratap Singh, Bahadur, Mohendra, Maharaja, Tikangarh: Prescott, E. M., Bannu: Pyari Mohun, Bareca, Minbu, Burma.

R

Radha Krishna, Cawnpore: Radhamohun Lal, Aligarh: Ragbhar Dial, Gohana, Rohtak: Raghbir Singh, Khikli, Lyallpur: Roghubir Dayes, Raghatat, Meerut: Roghunandan Dikshit, P., Sarila, Bundelkund: Roghunath Prosad, Pandit, Karauli, Rajputana: Rohimali, Gujarkhan, Rawal Pindi: Rohim Ulla, Ferozepore: Rait, J. W. F., Purnea: Raja Ram, Garhi, Kashmir: Raja Ram, Panipat: Rajendra Mitra, Gadarwara, Narshingpur: Raj Narain, Pandit, Tijara, Alwar: Rala Ram, Dattakhel, Bannu: Rama Chandra, Paratwara, Ellichpur: Rambhajanlal, Bindki, Fatehpore: Ram Bhrosa, Kamalia, Montgomery: Ram Chand, Eminabad, Gujranwala: Ramchand, Kotkapura, Faridkot: Ram Chand, Amritsar: Rama Chunder, D., Saugrur, Jhind: Ram Chandra, Dhaimsony, Bissan, Jaipur: Ram Dass, Pind Dadan Khan, Jhelum: Ram Dass, Kakar, Chamba: Ram Dayal, Lucknow: Ram Krishna Rao, Pundit, Kosi, Muttra: Ram Labhaya Mall, Sargodha, Shahpur: Ram Lakshman Bhakkar, Mianwali: Ram Halir, Lachiwala, Dehra Dun: Ram Lal, M., Fatehgarh, United Provinces: Ram Naryan, Orai, Jalam: Ram Pershad, Ajmere: Ram Pershad, Ajmere: Ram Pershad, Gwalior Station, Jhansi: Ram Rachpal, Private, Delhi: Ram Ratan, Dehra Dun: Rama Rathna Pathak, Benares: Ram Saran De, Patharkardi, Sylhet: Ramsaran, Delhi: Ram Singh, Khajuri, Tochi: Ram Singh, Bukshi, Ferozepore: Ranjit Singh, Chota Simla: Raushan Din, Montgomery: Ray, Mahendra Nath, Berhampore (Murshidabad): Reed, C., Kohat: Rendell, J. T., Pendra Road: Rennell, E. M., Pauri, Garhwal: Renill, W., Srinagar: Rennick, R. H. F., Kulu Valley, Kangra: Reve, J. G. S., Pathankot, Gurdaspur: Ricketts, H., Attock: Roberts, R. F., Bareilly: Robertson, H. C., Ambala: Robey, P. E., Dehra Dun: Robinson, G. W., Multan: Roderick, A. J., Tezpur: Rose, A., Dalao Cachia;

Rose, W. J., Nowshera, Sialkot: Roshanlal Udawat, Pokaran, Marwar: Roy, Sree Charan, Barisal: Rozario, E. D., Akyab, Burma: Rufus, A., Srinagar: Rushton, E., Mrs., Rurki: Rushton, W. H., Rurki: Ryan, F. C., Meerut: Ryder, C. H. D., Dehra Dun.

S

Sahai, R., Ghaziabad, Meerut: Sahasrabudhe, M., Amraoti: Sahibzada Hamiduzzafor Khan, Jodhpur: Salig Ram, Barmer, Jodhpur: Saligram Naga, Hamirpur: Sansar Singh, Ranipur, Saharanpur: Sant Ram, Pattan, Kashmir: Sand Ram, B., Amballa: Sannyasy, Maymyo, Mandalay: Sanyal, Hem Chandra, Kandi, Murshidabad: Sanyal, K., Bogra: Sarada Kanta Banerjee, Cherapoonjee: Sardar Ahmed, Multan: Sarat Chandra Dev, Nowgong: Satish Chandra Sen, Dhubri: Satnarain Lal, Mungra, Badshalpur, Jaunpur: Saunders, W. J., Meerut: Savedra, A. G., Ferozepore: Scaife, R. E., Srinagar: Schonemann, F. W., Aliwad and Amritsar, Amritsar: Schonemann, F. W., Aliwal, Gurdaspur: Schonemann, F. W., Amritsar: Seddon, T., Mian Mir: Seymour, M. A., Miss, Dwarahath, Kumaon: Shadilal, Hansi, Hissar: Sham Lal, Jagadhri, Ambala: Sham Singh, Chhaoni, Jhalrapatan: Sham Nath, Pandit, Ajmere: Shambhoodayal, Lucknow: Shankarlall, Rhotakmandi, Rohtak: Shankarlal, Jhansi: Shankara, R. S., Amballa: Shanker Dayas, Rosa, Saharanpur: Shanker Rao, Sagor: Shanon, C. H., Mussoorie: Sharpe, C. A., Marh, Balochan, Gujranwala: Shaw, Jagat D., Cossipore, 24-Parganas; Shaw, G. L., Arrah, Shahabad: Shaw, H. G., Dehra Dun: Shawe, E., Dr., Nijemo, Ladak, Kashmir: Shekh Ashrif Ali, Jhujjar, Rohtak: Sheppard, S. H., Rurki: Sher Mahomed, K. B., Kotta, Lodian, Dera Ismail Khan: Sher Singh, Ranikhet, Almora: Sherwood, H. J., Rurki: Shiam Lal, Bharatpur, Rajputana: Shiamkishan, Pherozeshaw, Quetta: Shiam, Manohar B., Lakhimpur, Kheri: Shib Dial, Rahon, Jullundar: Shivshanker Dube, Pandit, Chiarawa, Jaipur: Shiv Ram Pandya, Kunch, Orai: Showers, H. L., Dhadur, Sibi, Baluchistan: Silberrad, C. A., Banda: Singha, R. C., Baramulla, Kashmir: Sircar, Ananda Prasad, Calcutta: Sita Ram, Dagshai, Simla: Sivadatta Pande, Fatehgarh, United Provinces: Smith, C. S., Kamptee: Smith, W. F., Ugbana, Lyallpur: Smith, J. B. G., Dadupur, Amballa: Smith, N., Naini Tal: Sohan Lal, Dadupur, Amballa: Sohan Lall, Ferozepore: Sohan Lall Kupur, Khewra, Jhelum: Sohan Singh, Kolakam, Kashmir: Solomon, I. A., Bharatpur, Rajputana: Soner, T. W. de, Saugor Island, 24-Parganas: Souza, T. W. de, Saugor: Spencer, A. P., Ahmedabad: Splane, E. C., Malakand: Sridat, Fatehpur, Jaipur: Sri Gopal, Mandi: Srimany, Bringeswar, Chandernagar: Sri Ram, Khangah, Dogran, Gujranwala: Stalki, J. W., Darjeeling: Stansfeld, C., Dharmsala: Steel, R. F., Bhuj: Standley, A. W. E., Bikaner, Rajputana: Stepone, Le G. A., Dibrugarh: Stevens, E. R., Dehra Dun: Stewart, D. M., Dera Ghazi Khan: Stewart, R., Jhelum: Strahan, G. A., Dehra Dun: Subal Chandra Saha Roy, Mymensingh: Sukh Dial, Daraban, Dera Ismail Khan: Sunder Narain, Banda: Suna Sharepung, Prince, K., Saugor: Suraj Bali Dikshit, Tehri-Garhwal: Suraj Bali Lal, Meerut: Sutherland, W. D., Akola: Swey, W. H., Naini Tal: Syed

Ahmed Ali, Moradabad : Syed Tayammal Hossain, Gokal, Muttra : Syed Zille Hossain, Tando Masti Khan, Sind : Sykes, J., Sitapur, Oudh.

T

Talati, M. M., Mount Abu, Rajputana : Talbot, W. S., Rajauri, Jammu : Tara Chand, Pandit, Ramgarh, Alwar : Taylor, F., Allahabad : Teckchand Lekraj, Jacobabad, Sind : Tela Ram, Thanesar, Karnal : Tendall, C. E., Pabur River, Simla : Thakar Das, Chilas, Kashmir : Thaneshwar, Kathgodam, Naini Tal : Thomson, D., Dandot Colliery, Jhelum : Thorpe, A. N., Dholpur, Rajputana : Thornhill, B., Srinagar : Thurly, J. W., Karachi : Tickell, R. H., Mardan, Peshawar : Tillard, P. H., Lucknow : Todd, R., Jodhpur : Tristram, C. E., Deoli, Ajmere : Troup, N. F. T., Kausanie, Almora : Tullock, J. C., Rambagh, Dehra Dun : Tulsi Ram, Nanpara, Bahraich : Tunbridge, J., Dulchipass, Kangra : Turnbull, S. D., Segpoora, Kashmir : Turner, W. R., Tajawala, Amballa : Tydeman, E., Nowshera, Peshawar.

U

Uman Asan, Ajmere : Usman Ghani, Mastuj, Chitral.

V

Varma, A. P., Sirsa, Hissa : Verri res, A. C., Fyzabad : Vredenburg, E., Panna.

W

Wainright, E. A., Mussoorie : Wakefield, S., Kurrum Valley : Walayet Hosain, Saharanpur : Wali Mahomed, Dera Ismail Khan : Walker, A. C., Fatehpur : Wall, F., Fyzabad : Wallace, E. J., Lakhimpur, Kheri : Warburton, W. J., Sanawar, Simla : Ward, J. A., Batala, Gurdaspur : Warde, C. P., Mokameh Ghat : Walsh, F. R., Ranikhet, Almora : Watling, F. H., Sambalpur : Wazir Sahai, Dehra Dun : Webster, J. E., Mymensingh : Well, S. A., Landikotal, Peshawar : West, J., Almora, United Provinces : West, W. E., Ranikhet, Almora : Wildeblood, H. S., Meerut : Wilkinson, R., Shillong : Williams, M. T., Muzaffarpur : Williamson, J. C., Landour, Mussoorie : Willoughby-Foster, R., Dehra Dun : Wilson, G., Watcha, Shapur : Winkfield, R. E., Calcutta : Whitwell, R. H., Bankipur : Woodside, J. S., Landour, Dehra Dun : Woolbert, U. R., Ajmere : Worman, W. S., Lahore : Wright, C. M. P., Sangri, Kashmir.

Y

Young, R. F., Sultanpur, Oudh.

Z

Zahur Ahmed, Syad, Bahraich, United Provinces.

PART II.

CHAPTER V.

I.—TIME OF EARTHQUAKE : RATE OF PROPAGATION.

Difficulties.

The determination of the exact time of the earthquake, as experienced at the epicentre and at other places scattered over the felt area, *i.e.*, the construction of co-seismal lines, has been beset with all the difficulties usually encountered in such enquiries.[1]

Sources of information.

The epicentral area itself, principally on account of its distance from the larger cities of Upper India, has supplied no trustworthy information on this point. For the rest of India, the information at my disposal has been derived from two main sources, namely, (1) the earthquake forms, which express the current general opinion, and (2) automatically registering instruments.

Standard time.

It may here be mentioned that the time-standard used in this discussion will be that of Madras, which is 5H. 20M. 59·2S. east of Greenwich. At the date of the earthquake it was the standard in use for railway and telegraph traffic,[2] and to it many of the contributors to the forms referred their accounts of the shock. Such was not, however, invariably the case, and a large number of recorded times are local, or are unaccompanied by any reference to the standard used.

Great irregularity of recorded times.

Over the greater part of provincial India the times of the recorded shock, even when referred to some standard, are so irregular (as will have been seen from the summary of the earthquake forms) that at a first glance nearly all must be deemed

[1] See R. D. Oldham, Mem. G. S. of I., Volume XXIX, page 53 *et seq.*

[2] After July 1905 it was changed to so-called "Standard Indian Time" which is *5h. 30m.* east of Greenwich.

untrustworthy, that is to say, from the point of view of the exactitude required by seismological observations. From certain considerations as given below, however, it became advisable to discuss these apparently irregularly varying times, inasmuch as it was thought that they might conceivably fit in with a particular current theory of earthquake propagation.

(1) As recorded in the Earthquake forms.

Harboe's Theory.

An elaborate interpretation of the irregularly varying times recorded for certain remarkable earthquakes has, among other reasons, led Harboe[1] to put forward the general theory that the focus of an earthquake is not a point, nor a line, but that it ramifies, with a varying degree of initial violence over nearly the whole of the seismic area, and that the shock is transmitted very rapidly along these focal lines, whilst out from them at right angles it travels very slowly. He has concluded that the true rate of propagation of the sensible shock is as low as 0·4 kilometres per second (= about ¼ mile per second), and that the much higher rate of 3·3 kilometres per second represents the speed through solid rock at some little distance below the surface, whilst other intermediate values are compounded of the rate of propagation of the disturbance along the complex origin and that of the wave motion set up by the disturbance.

In consequence of the suggestion made to the author that the very varied values for the time given in the returns of the present earthquake might also furnish evidence tending to support this, a scrutiny of the time-values was instituted with this object,—but with a different result.

Daily time-signal in India.

Shortly before 4 P.M. every day, when telegraph traffic is at its lowest, all the telegraph operators in India are supposed to get ready to receive the time-signal at 4 P.M. issued at the Madras Observatory. Theoretically, therefore, the time at all telegraph stations in India thus served should be uniform,

[1] Erdbeben-Linien (Beiträge zur Geophysik, V, p. 206). See also letters in *Nature* of 26th April 1906, by R. D. Oldham.

within a few seconds of error.[1] Unfortunately the human equation of error, and also the individual clock errors spread over the hours elapsing since 4 P.M of the preceding day must have had an incalculably large influence on the registration of those times as recorded in the earthquake forms, for, an examination of the latter shows them to be inconsistent with one another. Leaving out of account all vaguely expressed or guessed times, and those given without any accurate reference to the standard taken (of which the number is legion), and taking for consideration only those substantiated with the statement that the time-piece had been checked with telegraphed Madras time (or railway time, which was then the same), it nevertheless is at once evident that the great majority, even of these so-substantiated times, are hopelessly unreliable. This is made plain from a mass of instances that might be given showing that in the same town or locality or district (if we are to credit the so-recorded times) the shock occurred at impossibly varying times.

General unreliability of the recorded times as entered on the earthquake forms.

A few examples will be sufficient to establish this :—

Locality.	Time, said to have been verified by telegraph from Madras.
Kashmir.	H. M.
Dras	5—50
Srinagar	6—10
Poonch	6—20
Astor-Gilgit road . . .	6—30

[1] Mr. G. T. W. Olver, Superintendent, Indian Telegraphs, informs me that at 15-55 all work on all lines is stopped, and beats are given for 4 minutes. When the actual time, 16 hours, is reached, the letter T (indicating "time") is signalled from Madras to certain main centres. At these the operators are all waiting, and at the signal they immediately repeat "T" again to further centres, and so on. At the most a loss of 1 second with each repetition might be expected.

Here the large difference of 40 minutes between the earliest and latest recorded times is an impossible condition, even in a large country like Kashmir : for we know sufficiently well that 5-50 is far too early even in the most epicentral area, and 6-30 is far too late, being long behind the most distant effects as recorded by level tubes and water movements on the very confines of the hardly felt shock. Consider also the following :—

Locality.	Time, said to have been verified by telegraph from Madras.
Ludhiana District.	H. M.
Ludhiana	6—4
Do.	6—10
Jagraon	6—15
Gujrat District.	
Gujrat	6—0
Do.	6—15
Bareilly District.	
Bareilly	6—9
Do.	6—12
Hazara District.	
Haripur	6—15
Mansehra	6—20
Rawal Pindi District.	
Murree	6—16
Rawal Pindi	6—11 (at end of shock).
Hissar District.	
Hansi	6—13
Hissar	6—15
Sirsi	6—10
Delhi District.	
Delhi	6—10
Do.	6—12
Do.	6—30

Locality.	Time, said to have been verified by telegraph from Madras.
Kheri District.	H. M.
Lakhimpur	6—10
Do.	6—15
Jaipur District.	
Jaipur	6—15
Do.	6—25
Jhunjhnu	5—55
Kotputli	6—11
Etawah District.	
Etawah	6—9
Do.	6—13.

Nearly all the above examples tell the same tale of mutual irreconcilability : in particular I would draw attention to the varying values furnished by different observers for the *same towns*, which are conclusive ; for time difference in the same town could only arise from one cause, namely, imperfect registration. Such differences for the instances mentioned above are respectively 6, 15, 3, 20, 5, 10 and 4 minutes, which give an average of 9 minutes.

Conclusion.

It is clear, therefore, in spite of their being substantiated, that no reliance can be placed on these recorded times, and no deduction drawn from them can have any weight, except the deduction that the ideas of time accuracy and the lack of conscientiousness of the operator or observer, as well as the poor time-keeping qualities of the clocks in use in many of the up-country offices, introduce so large a measure of error that their evidence is useless from the point of view of learning anything new about the rate of transmission of the earthquake waves so recorded. The fact of the matter is that over the greater part of provincial India uniformly co-ordinated time is not yet recognised as a necessity, and therefore in spite of the well-meant daily signal it is not, as a matter of fact, kept.

In large or important centres the recorded times are less irregular.

On the other hand in very large or important cities, especially those situated on main lines of railways, we begin to see a closer grouping of the recorded times of large numbers of observers round some common centre.[1]

The best examples of these are furnished along the great stretch of plain country within the neighbourhood of isoseist No. 7, and lying between Lahore and Saharanpur, a stretch of country which includes many important cities that are also railway centres connected by the main lines of railway in this part of India, and for which therefore accurate time would be a natural desideratum. Certain other centres of importance, such as Simla (the summer head-quarters of the Government of India) and Mussoorie and Dehra Dun, also exemplify the same thing, and make it abundantly clear that uniformity in the times recorded is primarily dependent on the places being of such importance in the official or commercial world that regular time-keeping may be presumed to have begun to be more or less a reality.

For instance :—

Locality.	Details of time.	
	H. M.	
Simla . .	6—10	by watch corrected every day by telegraph office.
Do. . . .	6—10	the mean of times shown by 10 pendulum clocks, which all stopped, and 4 watches.
Do. . .	6—10	watch regulated by telegraph office.
Do. . .	6—9½	time as given by meteorological observer.

Although it may be that the last value is the most correct, we see from the above only a variation of half a minute in all times that have been substantiated by reference to a fixed standard.

[1] The same fact is very noticeable in the case of the severe aftershock of 28th February 1906 where such times could be compared with those of the seismographs which were then installed at Simla. (See page 366.)

Compare also the following :—

Locality.	Details of time.	
	H. M.	
Lahore . .	6—10	by railway station clock in telegraph office, stopped. It was corrected every day by signal from Madras.
Do. . .	6—10	by 2 platform drum clocks in railway station, which are put right every Monday with the telegraph clock.
Do. . .	6—7	by watch compared with North-Western Railway station time.
Do. . .	6—12	by Government watch keeping accurate time and often compared with observatory clock.
Mian Mir (Lahore Cantonment).	6—10	by watch in accordance with telegraph time.
Jullundur .	6—10	by railway station telegraph clock, corrected by daily signal from Madras.
Amritsar . .	6—10	by watch timed at railway station.
Do. . .	6—8	by railway station platform clock stopped (not certified correct).
Do. . .	6—11	by 2 pendulum clocks stopped, regularly checked by railway time.
Dehra Dun ..	6—10½	by turret clock in Survey of India Office, stopped. (See also page 90.) A correction of +34 seconds is stated to be required.
Do. .	6—10	by watch correct with turret clock.
Do. .	6—12	by excellent clock in time with turret clock.
Mussoorie and Landour.	6—11	Government telegraph clock stopped, said to be correct.
Do. .	6—10	by new watch correct with telegraph time.
Do. .	6—10	by watch constantly corrected by telegraph time.
Do. .	6—14	by watch compared on same day with telegraph time.
Saharanpur .	6—11	by chronometer watch checked at the time on railway platform.

If we consider as in the preceding case the extreme time differences for all individual towns where more than one observation is recorded, we have as follows ½, 5, 3, 2, 4 minutes respectively, which give an average of 3 as against 9 in the preceding cases. And this method of comparison neglects the fact that very many recorded times are in absolute agreement.

Harboe's theory not confirmed.

Summing up the evidence for the time as given in the earthquake forms by observations said to be substantiated by reference to the standard then in vogue, we find that it in no way confirms Harboe's theory of a complex ramifying "spider's web" centrum, from which the felt waves spread slowly into the intervening areas. It certainly gives evidence for a condition of a somewhat similar nature as regards the times, but one whose complex ramifying lines are in reality those coinciding with important towns or railway communication, along which more accurate time-keeping has become customary; whilst the intervening areas, instead of being those where the felt waves spread slowly, become merely those where irregularity of quite another sort occurred, namely, in that of the sending, registering or correct referring of the daily time signal. The unequal transmitting power that operated was not inherent in the rocks but rather in the machinery of time registration.

From information kindly supplied me by Mr. G. T. W. Olver, Superintendent, Indian Telegraphs, I am able to give the following details of the stations where the daily time signal is repeated on its way to the towns mentioned in the preceding lists. It will be seen that a loss of 4 or 5 seconds is the utmost that should occur in transmitting the signal if ordinary attention is observed. The following abbreviations are used: Ms.=Madras, By.=Bombay, Lh.=Lahore, Sk.=Srinagar, Ag.=Agra, Rp =Rawal Pindi, Dhi.=Delhi, Lkw.=Lucknow.

Locality.	Repeating stations.
Dras	Ms., By., Lh., Sk.
Srinagar	Ms., By., Lh.

Locality.	Repeating stations.
Poonch	
Astor-Gilgit road ..	Ms., By., Lh., Sk.
Ludhiana	Ms., By., Ag., Amballa.
Jagraon	Ms., By., Ag., Amballa, Ludhiana.
Gujrat	Ms., By., Lh.
Bareilly	Ms., By., Ag.
Haripur	Ms., By., Ag., Rp., Abbottabad.
Manschra	Ms., By., Ag., Rp.
Murree	Ms., By., Lh.
Rawal Pindi	
Hansi	
Hissar	Ms., By , Dhi.
Sirsi	
Delhi	Ms., By., Lkw.
Jaipur	Ms., By., Ag.
Jhunjhmu	
Kotputli	Ms., By., Lh.
Etawah	Ms., By., Ag.
Simla	
Lahore	Ms., By.
Mian Mir	Ms., By., Lh.
Jullundur	Ms., By., Ag., Amballa.
Amritsar	Ms., By., Lh.
Dehra Dun	
Mussoorie	Ms., By., Ag.
Landour	
Saharanpur	Ms., By., Ag., Rp.

Caution.

It should be understood that the results arrived at in this examination of the times are only negative as regards Harboe's theory: they simply do not support it. On the other hand, that some delay in transmission at the very surface is effective in the mountainous parts seems likely (see p. 306). It is conjectured, however, that these slow moving surface waves are propagated only a very small distance before they become smothered by free movement, and it seems to the author doubtful whether they could have any noticeable effect on the great plains of India.

Regular radial progression of the shock.

With the above exception, it becomes evident that the earthquake-form time-records, though untrustworthy in detail (especially in the more outlying towns and districts) when considered as a whole, and when special credence is given to important centres where many substantiated observations agree with each other, contain nothing to discredit the regular radial progression outwards of the shock from the epicentral region towards the circumference of the felt area. And these finally are in agreement with the few specially trustworthy automatically recorded times provided by the seismographs (see p. 291).

(2) Special Instrumental Records.

Seismograph and magnetograph records.

These are derived primarily from the seismographs of the Milne type in the meteorological observatories of Bombay (Colaba), Kodaikanal in the Palni Hills and Calcutta (Alipur), and secondarily from magnetographs in the observatories at Bombay (Colaba), Dehra Dun, Barrackpore and Toungoo.

If recent criticisms of seismographic records is to be trusted (as to which specialists in this branch of science can alone speak with particular knowledge), the Milne seismograph trace, which is very small and often blurred[1] cannot be trusted to show all those minute sub-divisions of regularly recurring period and amplitude which the larger forms working with a large natural period of swing, register by means of a needle point on smoked paper, and which give an open or large time-scale diagram.[2]

The so-called preliminary tremors as seen in long-distance seismograms written by the Milne instrument, are, however, fairly well differentiated from the large movement which follows. The splitting of the preliminary tremors into two groups, first and second, is also

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1 It depends on a reflected spot of light impinging on sensitised paper, and this it appears may not always be bright and sharp.

2 See "Publications of the Earthquake Investigation Committee in Foreign Languages" No. 24, p. 26, also "La Science Seismologique," by Le Comte de Montessus de Ballore, p. 40.

believed by many to be sufficiently recognisable. However that may be, the beginning of the large movement is the only definite point that can be reasonably correlated with the sensible earthquake wave or shock as felt in its progression from place to place over the surface of the affected area.

Time of commencement of large movement on seismograms.

The times of commencement of the large movement in the Indian seismographic records of the Kangra earthquake are as follows :—

		H. M. S.	
Bombay (Colaba)[1]	..	6—17—29	mean of two measurements
Kodaikanal	..	6—21—48	
Calcutta (Alipur)	..	6—17—5·2	

and if for the present we take 6H. 9M. as a probable time for the beginning of the shock in the centre of the larger and more important Kangra epicentre, we have —

	Distance in miles from centre of large epicentre.	Seconds during transit.	Deduced rate in miles per second.
Bombay (Colaba)	950	509	1·87
Kodaikanal ..	1,497	768	1·95
Calcutta (Alipur)	950	485	1·96
			Mean.. 1·92

Since Bombay and Calcutta are the same distance from the epicentre, we can by taking a mean of the two times of arrival at those places and subtracting it from the time of arrival at Kodaikanal, obtain a fresh rate of transmission which is independent of the more or less guessed time at the epicentre. Thus 547 miles in 271 seconds gives a rate of 2·02. Or working out the two rates independently according to the time values at each of the places Bombay and Calcutta, we get rates of 2·11 and 1·93 respectively. The former rate, if continuously

1 The values given here differ slightly from those given in my preliminary report being the final determinations as printed in the Monthly Weather Review for April 1905.

maintained from the epicentre, would give a time of commencement of 6H. 9M. 59S. and the latter 6H. 8M. 52S.

The latter very closely agrees with the time provisionally taken as correct at the epicentre, namely, 6H. 9M. being based on the time given as 6H. 9½M. at the Simla Meteorological Office and on the large amount of evidence for 6H. 10M. in the cities lying about isoseismal VII between Lahore and Saharanpur.

Clocks stopped in Calcutta.

Besides the above time of 6H. 17M. 5·2S. recorded at Calcutta, we have further corroborative times afforded by Mud Point and Saugor Island, which agree in giving 6H. 17M. 0S. Other time evidence in Calcutta that may be mentioned here has been derived from the stoppage of clocks. At St. Xavier's College the electric clock stopped at 6H. 20M. 0S.; at Alipur Observatory the astronomical clock stopped at 6H. 19M. 0S.; but it is important to remember that so far from the centre as Calcutta, where the shock was necessarily very weak, it is probable that these clocks did not stop all at once, and therefore that they considerably overstate the time.

Magnetograms.

Evidence derived from the examination of the magnetograms at Dehra Dun, Bombay, Barrackpore and Toungoo by the Survey of India Officers in collaboration with Prof. Omori show, however, a possible modification of this which would fix the time at the epicentre as 6H. 10M. 43S.

The following is a report by Captain R. H. R. Thomas, R.E., on the subject :—

ON THE TIME OF THE PRINCIPAL EARTHQUAKE SHOCK ON THE 4TH APRIL 1905 AS REGISTERED ON MAGNETOGRAPH CURVES.—BY R. H. R. THOMAS, CAPTAIN, R.E.

The accuracy of measurements.

For the purposes of the magnetic records no minute accuracy in time is required. The shortness of the time scales, *viz.*, about 0·6 inch for one hour precludes accurate measurements to more than one minute, ·01 inch being equivalent to that amount.

The process of measuring the exact moment of time of a particular point on the trace is burdened with several sources of error in the measurement of small quantities. These are as follows :—

(1) Error of zero of measurement—the verticals on the glass scale being lines of a certain thickness, it is difficult to place the vertical line

immediately over the point of measurement. It was subsequently found to be better to place the zero line to one or other side and measure the departure.

(2) Errors in measuring quantities smaller than 10 minutes, this being the smallest division of the glass scale.

(3) Error in determining the corrections to glass scale.

(4) Error in measuring the parallax of the curve, being the small quantity by which the time scale overlaps the curve or *vice versâ*.

(5) Error in estimating the number of seconds before or after the hour at which the cut off falls, the driving clock being unprovided with a second hand.

Considering all these sources of error, which in the most unfavourable case are cumulative, it would not be excessive to regard the probable error of a single measurement as ±2 minutes, though in many cases fortuitous cancellings would operate to produce results far closer to the truth.

The accordance however of many of the results in the following pages, when independent measures were taken by two or more observers, is such that there should be no hesitation in accepting some groups as correct at least to 1 minute time.

There is moreover a check on the times found for each observatory by comparing the intervals derived from the time of shock at each observatory with the intervals obtained by measuring the interval between the shocks and the well marked apices of disturbances on the same date. This method assumes that the times of disturbance are simultaneous but, in view of the measurements of the disturbances and the fact that such disturbances are proved to be simultaneous over large areas, the assumption is not unwarranted. Two apices of disturbance have been utilized and the measurement has been made in two ways.

An additional advantage applies to these methods in that error of cut off parallax and error of clock are not involved.

In the first the absolute time of the apex of disturbance is found and the time interval derived by applying the absolute time of the shock already determined.

In the second the interval is measured direct and the only sources of error are in the measurement of the small quantity by which the time is in excess of or defect of a 10-minute division of the glass scale and in the correction to the length of the glass scale itself.

This method probably gives the closest approximation to the interval of time between the registration of the shock at different observatories and hence the velocity of transmission.

If then 2 and 3 give results fairly in accordance, it will probably be best to accept the time intervals given by 3 as being correct and then compare these with the measurements of the time intervals obtained by the direct measurements of the times of shocks.

This should give an indication of the correctness or otherwise of the assumed chronometer errors.

Methods of obtaining time at the various observatories.

(2) Before tabulating the results of the measurements of the magnetograms and comparing them as above suggested, it would be well to briefly indicate the methods of obtaining correct time at the various observatories.

At Dehra Dun time is obtained by comparison of the observer's chronometer with the sidereal clock at least twice a week, errors on the days being interpolated by the rates thus obtained.

At Barrackpore and Toungoo time is obtained by observations to E. and W. stars.

At Kodaikanal time is obtained by telegraphic signal from Madras daily and the observer's chronometer is compared daily with the Solar Physics observatory clock. At all observatories the driving clock of the magnetographs is compared daily with the standard chronometer by means of a pocket chronometer, but as before stated in the absence of a second hand on the driving clock this determination is likely to be in error some seconds.

TIMES OF PRINCIPAL SHOCK MEASURED FROM MAGNETOGRAPHS.

I.—*Direct measurement of time of shock corrected for errors of clock, parallax and cut off.*

[All in Madras time. H from H.F. curve δ from declination curve.]

		Thomas.		Mazumdar.		Omori.	
Dehra Dun.	(H)	6-11-43	6-11-46	6-11-29	6-11-37	6-11-27	6-11-30
	(δ)	6-11-48		6-11-46		6-11-33	
	Mean.	6-11-38.					
	(H)	6-16-12	6-16-39	6-16-26	6-16-38	6-16-29	6-16-43
	(δ)	6-17-5		6-16-50		6-16-55	
	Mean.	6-16-41.					
Kodaikanal.	(H)	6-21-40	6-21-52	6-21-37	6-22-7	6-21-30	6-22-0
	(δ)	6-22-4		6-22-36		6-22-30	
	Mean.	6-22-0. The Kodaikanal H.F. trace is very faint and difficult to measure.					
Toungoo.	(H)	6-20-3.		6-19-45		6-19-58	
	(δ)	Very faint not measured.					
	Mean.	6-19-55.					

			M. S.
These give intervals—	Dehra Dun to	Barrackpur	5-3
	Do.	Kodaikanal	10-22
	Do.	Toungoo	8-17

or separately for the three observers;

		H.	δ.	Mean of H and δ
Dehra Dun—Barrackpur.	T.	4-29	5-17	4-18
	M.	4-57	5-4	5-0
	O.	5-2	5-22	5-12
Do. —Kodaikanal	T.	9 57	10-16	10-7
	M.	10-8	10-50	10-29
	O.	9-57	10-57	10-27
Do. —Toungoo.	T.	8-17		
	M.	8-8		
	O.	8-28		

II.—*Measurement of time interval between apex (a) of disturbance and time of shock.*

(1) Absolute time of apex of disturbance (*a*)—

	Dehra Dun.	Barrackpur.	Kodaikanal.	Toungoo
Thomas	. 9-12-27	9-12-22	9-12-5	9-11-7
Mozumdar	. 9-12-17	9-11-55	9-12-36	9-11-15

Substracting the values of each observer for the time of principal shock we get

	Dehra Dun.	Barrackpur.	Kadaikanal.	Toungoo.
Thomas	. 3-0-41.	2-55-43.	2-50-13.	2-51-4.
Mozumdar	. 3-0-40.	2-55-27.	2-50-29.	2-51-30.

This gives times for interval.—

		M. S.
Dehra Dun—Barrackpur	T.	4-58.
	M.	5-13.
Do. —Kodaikanal	T.	10-28.
	M.	10.11.
Do. —Toungoo	T.	9- 37.
	M.	9-10.

(2) Direct measurement of time interval—

	Dehra Dun.	Barrackpur.	Kodaikanal.	Toungoo.
Thomas	3-0-32	2-55-18	2-50-10	2-51-0
Mozumdar	3-0-28	2-55-25	2-50-24	2-51-5

		M. S.
Giving times for Dehra Dun—Barrackpur	T.	5-14
	M.	5-3
Do. —Kodaikanal	T.	10-12
	M.	10-4
Do. —Toungoo	T.	9-32
	M.	9-23

III.—Absolute time of apex of disturbance (b).

(1).	Dehra Dun.	Barrackpur.	Kodaikanal.	Toungoo.
Thomas	2-31-46	2-31-40	2-31-45	2-30-35

Subtracting time of principal shock we get—

Dehra Dun.	Barrackpur.	Kodaikanal.	Toungoo.
3-40-0	3-44-59	3-50-15	3-49-38

giving—

	M. S.
Dehra Dun—Barrackpur	4-59
Do. —Kodaikanal	10-15
Do —Toungoo	9.38

(2) Direct measurement of interval from apex (*b*) to principal shock—

	Dehra Dun.	Barrackpur.	Kodaikanal.	Toungoo.
Thomas	3-39-51	3-44-54	3-49-55	3-49-16.

giving differences

	. S.
Dehra Dun—Barrackpur	5-3
Do. —Kodaikanal	10-4
Do. —Toungoo	9-25

IV.—Absolute times of disturbances.

As found these are—

	Distance (*a*).		Distance (*b*).		Difference (*b—a*).
Dehra Dun	2-31-46	Mean 2-31-44	9-12-22	Mean 9-12-7	6-40-36
Barrackpur	2-31-40		9-12-9		6-40-29
Kodaikanal	2-31-45		9-12-20		6-40-35
Toungoo	2-30-35		9-11-11		6-40-36

	M. S.	M. S.
Difference Mean	1-9	1-8
Toungoo	1-6	

This proves that the disturbances are simultaneous at all observatories within the limits of measurement and that Toungoo time is slow, 1M. 8S., while the time at the other three observatories is very good.

This conclusion is further borne out by consideration of the intervals Dehra Dun—Toungoo by the two methods of measurement.

	Dehra Dun—Toungoo. M. S.	
(1) By direct measurement of time of shock . .	8-17 8-8 8-28	Mean 8-18
(2) By measurement from disturbances (which eliminates error of clock).	9-37 9-10 9-32 9-23 9-38 9-25	Mean 9-27

or Toungoo time slow 1M. 9S. and mean correction to Toungoo = +1M. 8S.

V.—Comparisons of the intervals of time found from Dehra Dun to the other observatories.

Dehra Dun—Barrackpur—

	M. S.		
(a) Direct measurement	4-48 5-0 5-12	Mean 5-0	5-3
(b) By measurement from disturbances . . .	4-58 5-13 5-14 5-3 4-59 5-3	5-5	

Dehra Dun—Kodaikanal—

(a) By direct measurement	10-7 10-29 10-27	Mean 10-21	10-17
(b) By measurement from disturbances . . .	10-28 10-11 10-12 10-4 10-15 10-4	10-12	

This shows that the clock times at Dehra Dun, Barrackpur and Kodaikanal are correct.

VI.—Final values of time of principal shock.

For the reasons shown by the tables in V there is no good reason for not accepting the times given for Dehra Dun, Kodaikanal and Barrackpur, the only correction is then to add 1M. 8S. to the Toungoo time.

The times then become—

	H. M. S.	
Dehra Dun	6-11-38	*Madras time.*
Barrackpur	6-16-41	
Kodaikanal	6-22-0	
Toungoo	6-21-3	

giving times from
Dehra Dun to :

	M. S.
Barrackpur	5-3
Kodaikanal	10.22
Toungoo	9-25

VII.—On the time of transmission derived from the times given in the preceding pages.

Assuming that the origin of the seismic wave was in latitude 32-0-0, longitude 77-0-0, the distances on the arc are--

Origin to;

Dehra Dun . . .	131 miles	= 211	kilom.
Barrackpur . . .	944 ,,	=1,519	
Kodaikanal . . .	1,498 ,,	=2,411	
Toungoo . . .	1,512 ,,	=2,433	,,

and Dehra Dun being close to the origin, the differences between distances Dehra Dun and the other observatories will closely approximate to the correct distances along the great circles from the origin to those observatories.

The velocities of transmission found are—

M. S.		
(5-3)	Dehra Dun—Barrackpur . .	2·7 miles per sec. 4·3 kilom. ,, ,,
(10-22)	Dehra Dun—Kodaikanal . .	2·2 miles ,, ,, 3·5 kilom. ,, ,,
(9-25)	Dehra Dun—Toungoo . . .	2·4 miles ,, ,, 3·9 kilom. ,, ,,
	or a mean velocity of	2·4 miles ,, ,, 3·9 kilom. ,, ,,

It follows from this that magnetographs do not register preliminary tremors error so close as 200 miles to the origin.

This velocity is intermediate between Prof. Omori's v_3 (4·6) and v_5, the surface velocity 3·3 kilometres per second derived from the observation of a number of earthquakes.

Applying this velocity to the distances Dehra Dun to assumed origin we get—

Time of earthquake at origin . . 6H. 11M. 38S.—55S.
=6H. 10M. 43S.

With reference to this Prof. Omori[1] writes :—

"Thus the time of earthquake disturbance as registered by the magnetograph at Dehra Dun was 0H. 50M. 38S. G. M. T., the approximate distance of that place

[1] Publications of Earthquake Investigation Committee in Foreign Languages, No. 24.

from the most central part of the epifocal zone being 1° 45′, or 195 kilometres. Within such an epicentral distance the velocity of propagation of the first preliminary tremor is probably 5 or 6 kilometres per seconds. If we assume the velocity to be 6 kilometres per second the time taken by the seismic waves in travelling the distance of 195 kilometres would be about 32 seconds. Now, as the magnetograph is not so sensitive as a seismograph, the time moment recorded at Dehra Dun might correspond to the commencement of the principal portion, the duration of the total preliminary tremor being probably some 20 seconds. Thus the time of earthquake occurrence at the epicentre may approximately be taken as 0H. 50M. 38S *minus* about 50 seconds, or 0H. 19M. 48S. G. M. T. [which is 6H. 10M. 48S. Madras time]."

Criticism of Captain Thomas' note.

With reference to Captain Thomas' note, however, I pointed out that with regard to his deduced times if we neglect the Dehra Dun time as being disputed we have by difference of time and space (using his own figures):—

Difference of time, Kodai and Barrackpore		319 secs.
Do	Toungoo and Barrackpore	262 ,,

Difference of radial distance from centre :—

Kodai and Barrackpore . . .	554 miles.
Toungoo and Barrackpore .	568 ,,
Rate in first case 554 ÷ 319 which is .	1·74 miles per sec.
2nd case 554 ÷ 262 . .	2·17 ,, ,,

Now these radial distances and times should at that distance from the epicentre give a uniform rate (approximately) which they do not, the difference amounting to nearly ½ mile per second. Also both are too low according to his own estimate. So that if from them we calculate backwards to the point of origin, namely, 1,498 and 1,512 miles respectively, we get 6H. 7M. 39S. and 6H. 9M. 26S. respectively for the time at the epicentre.

The above reasons make me hesitate to accept the results of the magnetogram readings as in any way contributing to our knowledge of the true time of the sensible shock.

In reply to this criticism Captain Thomas quite agreed to the principle of deducing rates by the difference method leaving Dehra Dun

time out, and he therefore had to admit the Dehra time inexplicable.[1]

Conclusion.

On the other hand the rates deduced from the times of arrival of the large movement in the seismographic records at Calcutta, Bombay and Kodaikanal are as we have already seen far more in agreement among themselves, the extreme difference of rate being only about $\frac{1}{10}$ mile per second instead of nearly $\frac{1}{2}$ mile per second. It seems, therefore, more logical to accept the mean of them, namely, 1·92 miles per second, as being the best rate obtainable. Whether the co-seismal lines (curves of equal time), especially near the epicentre, are irregular or not in their courses round the central region cannot be actually known : the number of absolutely accurate time observations have been shown to be too few for such fine distinctions. But it is probable that such irregularity is not great, and that the curves, therefore, approximate to regular concentric circles round the epicentre. It has certainly been shown that any argument against this conclusion based on the markedly irregular times as recorded locally in up-country stations, can have no weight because of the untrustworthy character of the latter.

II.—THE ISOSEISTS : INTENSITY AND CHARACTER OF THE SHOCK.

Varying surface intensity.

Following on the time and speed of the shock, the next aspect of the earthquake that will be considered here is its areas of varying surface intensity. Of these it may be said that, whilst a systematic delineation of them on the map is one of the main functions of a survey, a correct appreciation of what they imply will perhaps lead us nearer to a satisfactory understanding of the earthquake than may be obtained along any other lines of enquiry.

This is so because the intensity of an earthquake shock is a very real and effective quality, and in studying its effects we are led

[1] Demi-official letter to me, dated 29th September 1905.

through zones of greater and greater destruction to the pleistoseismic area which must lie above the place of origin.

No one doubts that the surface during an earthquake is in a complicated state of molecular strain and movement, the earth particle (as revealed by seismographs) swinging in ever-changing paths that yield, as factors, the period, velocity, amplitude and acceleration of that particle. These vary in amount at different places, generally increasing as regards the energy involved and the damage caused to buildings, etc., up to some point, line, plane or other epicentral surface-feature, from which also the time records frequently show that the movement sprung and spread.

But, beyond this, if we try to analyse directions of shock as felt by observers, as evinced by swaying and fallen objects, or as deduced from strains resulting in fissures that have been set up in all solid objects resting on the earth, and even the surface of the ground itself; and if we try to square that analysis with theoretical speculations as to what the nature of the wave or waves started by the seismic impulse ought to be—then do we find ourselves entangled in a hopeless mass of irreconcilable data. At least such seems to be the prevailing experience among many students of earthquakes, and it is certainly borne out by the study of the present earthquake.

Whether, then, the original impulse is condensational and in the direction of propagation of the shock, or distortional and transverse to it, or both; whether such wave or waves reach the surface by this or by that path, and with varying speeds or not—current explanations regarding which the writer thinks do not yet thoroughly accord with facts—need not be considered for the purposes of this descriptive memoir. Assuming a below-the-surface origin for the shock, the first news we really have of it is as expressed at the surface of the ground in damage which varies in character and intensity. To the general description and summarising of this, accompanied by a few remarks on the character of the wave motion as so expressed or recorded in the various isoseismal compartments I now propose to turn.

Isoseismal lines.

Compared with that of the co-seismal lines our knowledge of the isoseismal lines (or curves of equal intensity) is sufficiently complete, at least in the more central areas, for them to be mapped in fair detail. This is so because of the less evanescent character of the evidence as expressed in the ruined towns, and because the principal areas in question were examined by the Geological Survey.

Intensity scale.

One of the special tasks undertaken by the officers of that department was this mapping of the areas of varying intensity in accordance with a standard intensity scale. The scale originally adopted was the Rossi-Forel, which is detailed below —

Rossi-Forel Intensity Scale.

(I) Recorded by a single seismograph, or by some seismographs of the same pattern, but not by several seismographs of different kinds; the shock felt by an experienced observer. [This number of the scale is now obsolete owing to improvements in seismographs.]

(II) Recorded by seismographs of different kinds; felt by a small number of persons at rest.

(III) Felt by several persons at rest; strong enough for the duration or the direction to be appreciable.

(IV) Felt by persons in motion; disturbance of movable objects, doors, windows; cracking of ceilings.

(V) Felt generally by every one; disturbance of furniture and beds; ringing of some bells.

(VI) General awaking of those asleep; general ringing of bells; oscillation of chandeliers, stopping of clocks; visible disturbance of trees and shrubs. Some startled persons leave their dwellings.

(VII) Overthrow of movable objects, fall of plaster, ringing of church bells, general panic, without damage to buildings. [Owing to poor material and construction in India damage to buildings is considered to begin here.]

(VIII) Fall of chimneys, cracks in walls of buildings.

(IX) Partial or total destruction of some buildings.

(X) Great disasters, ruins, disturbance of strata, fissures in the earth's crust, rock-falls from mountains.

Higher and lower intensities differently determined.

So far as the higher intensities of VII, VIII, IX and X are concerned, this mapping, it is believed, has been successfully accomplished. It was, however, hoped that a critical examination of the effects as detailed in the earthquake forms would have enabled the lower intensities, VI, V, IV, III and II to be similarly inserted on the map over the unvisited areas. With this object the individual forms were all separately valued, each on its own internal evidence, and the numbers assigned were afterwards entered on the map. It was then found that not only were there great gaps in the more circumferential regions, but also that the figures covering the well-reported area showed a considerable intermingling.[1] The lower isoseists therefore and with them isoseist VII have been finally grouped together as follows :—

Grouped members of the Rossi-Forel scale.	Definition taken here.
II and III	Felt by a few sensitive people lying down or favourably situated.
IV and V	Generally noticed, no damage. Shaking of beds, etc.
VI and VII	Universally felt. Upsetting of small, loose objects. No damage, except in rare instances, to burnt brick structures. Small cracks and damage to sun-dried brick and mud buildings which are so common in India.

1 It must also be confessed that the figures allotted were in many cases rather arbitrary on account of the difficulty in rural districts of correlating such purely European standards as ringing of church and house bells, swinging of chandeliers and cracking of ceilings.

Identical with Oldham's grouping for the 1897 earthquake.

The resulting lines are shown on the map (pl. 28). This is in effect the grouping adopted by Oldham in his account of the Assam earthquake of 1897, except that that author numbers the isoseismals from the centre outwards as 1, 2, 3, 4, 5, and 6, instead of in the reverse direction.

The various isoseists will now be described according to their lie, the areas enclosed by them and the energy and character of the wave within them.

Isoseist No. X.

(1) Description and general Intensity.

Areas and boundaries.

The innermost isoseismal line, No. X, of the Rossi-Forel scale encloses an area of about 200 square miles. Its curve roughly cuts Dharmsala, Rehlu, Daulatpur, Bawarna and Palampur, but its E. S. E. edge was found to be ill-defined. We have seen that it includes much of the Kangra valley and portions of the lower slopes of the Dhauladhar range.

Nature of evidence.

With the exception of this rather vague E. S. E. edge, no one who was familiar with the effects of the earthquake would have much doubt about the limits of the rest of this area. In all the outlying areas, destruction to life and property, though it might be great, was never so sweeping as within isoseist X. What were merely destroyed or ruined[1] villages within the IXth isoseist become, within the Xth, flattened and levelled heaps of débris. In the former one might wander amongst the ruins, in the latter one could walk over the prostrate remains : in the former the better built bungalows, constructed on European lines, could occasionally be partially utilised—a room here or a verandah there remaining standing, whilst in the latter at Dharmsala, Kangra and Palampur, etc., all the surviving inhabitants were forced into tents or temporarily erected shelters.

Within isoseismal X also, only the strongest structures survived intact, such as the Dharmsala magazine and treasury ; whilst all buildings of ordinary great strength, such as the European barracks at

[1] For definition of term see p. 8.

Dharmsala, Rehlu Fort, well-built court-houses, travellers' bungalows, police stations, jails, tea factories, mission houses, churches and massive temples alike were destroyed.

In the case of the ordinary sun-dried brick and slate roofed bazar the total destruction which occurred may be said to have been a foregone conclusion, as it was also a characteristic of the region.[1]

Opinion of survivors.

The experiences of survivors within this area agree in recording the terrific nature of the shock and that it was accompanied by the loudest sounds. It was above all others the area most fatal to human life, the area whence issued nearly all the tragic stories of sudden death, of entombments and gallant rescues. The Kangra and Palampur Tehsils alone had 10,000 and 3,000 deaths respectively, which is about $\frac{1}{10}$ the whole population.

Evidence of overturned *Sikras*.

But perhaps the most concrete evidence is afforded by the many overturned or partially overturned stumpy spires, or *Sikras*, belonging to early Hindu temple art. As described and illustrated (p. 37 and elsewhere), these rather uniform, stoutly built, stone structures, so common in this part of India, have only been overthrown within isoseismal X.

Intensities greater than X not observed in this earthquake.

It is, in short, believed that the evidence recorded in the descriptive portion of this report is sufficient to allow the delineation of isoseismal X in terms of the Rossi-Forel scale. The intensity there displayed, as interpreted by the destruction, seems to be the maximum for ordinary world-shaking earthquakes of presumed deep-seated origin, excepting only those like the Assam quake of 1897 and the Japan quake of 1891 which were accompanied by surface displacements on level ground, and which carried in their train fault-scarps, destruction of railway tracks and iron girder bridges, the bending and snapping of trees and other destructive effects on vegetation—in all of which cataclysmic effects the Kangra earthquake fell short of those just mentioned.

[1] Prof. Omori mentions a similar result in the case of the Formosa earthquake, 17th March 1906. See Bull. Imperial Earthquake Investigation Committee, Volume I, No. 2, p. 55.

Geographical Index.

The map will show the general position of isoseist No. X and the following list of chief towns within that boundary arranged alphabetically will further explain its range :—

Places within Isoseist No. X.

Name of town or village.	District.	Lat. N.—Long E.	Distance in miles from nearest point of main epicentre.
Bawarna	Kangra . .	32° 3′—76° 33′	All within a few miles.
Chari	Do. .. .	32° 12′—76° 19′	
Daulatpur . . .	Do. . .	32° 3′—76° 19′	
Dharmsala . . .	Do. . .	32° 13′—76° 24′	
Kangra	Do. . .	32° 6′—76° 19′	
Nagrota	Do. . .	32° 7′—76° 26′	
Palampur	Do. . .	32° 7′—76° 36′	
Rehlu	Do. . .	32° 13′—76° 16′	

(2) Character of the Shock within Isoseist X.

At Dharmsala.

It seems likely from a general consideration of damage done and reports furnished, that the earthquake motion which destroyed the most of Dharmsala was a very complex one. The inequalities of the surface, and the great damage on ridges, spurs, steep slopes and convexities, seem to show that the motion at these actual surfaces was a compound of molecular and molar motion: that the waves belonged to that large, slow-travelling, semi-gravitational class which become manifest when traversing loose superficial material that has a low modulus of elasticity and numerous free surfaces. Through such rocks, near the surface, the amplitude would be gradually increased and with it the period, owing to the inferior powers of resistance and recoil among the particles of these more or less disintegrated and soil-cap covered localities.

Being of this character it is evident that the sensible shock on every spur and ridge and elevated plateau lost way by visible displacement, disruption, crumbling, loosening and spreading out of the superficial rock and soil-cap—for which there is considerable evidence in the fissures in the hillsides and the special damage there done;

whilst, on the other hand, in the hollows and bays in the hills, together with some valley bottoms having support all round, no such visible movement has occurred and they may be considered as areas of relief or "shadows," or places where the shock had either spent or neutralised itself by interference.

The same thing is borne out by the upsetting of the barracks and other buildings in a down-hill direction round the long and winding hill spurs, no matter what point of the compass was indicated—a fact which incidentally shows how hopeless is the task of using directions of fall of buildings, even of such symmetrical structures as the magazine and Lord Elgin's tomb in looking for evidence pointing to the central line of the disturbance.

The case of the other tomb and gate pillars in the church-yard that had rotated on their bases is interesting as possibly indicating a twisting movement of the ground, although it does not appear that such effects are necessarily produced in that way.[1]

The projection of the cross from the east gable-end of the church, a horizontal distance of $37\frac{1}{2}$ feet from a height of only 32 feet, testifies to the great swing the latter must have acquired before it and the upper 10 feet of the gable-end were shot away. From the formula $v=\sqrt{\frac{a^2g}{2b}}$ where a is the horizontal distance and b is the vertical distance, we obtain the value $v=26\frac{1}{2}$ feet per second, as the horizontal velocity with which these objects started, as they were flicked or slung off their supports. Such velocity is of course a greatly magnified representation of that of even the surface wave-motion at this place.

Statements of eye-witnesses.

Coming now to testimony supplied by eye-witnesses as recorded in the earthquake forms and newspapers, we find a comparatively small number of observations on which to work. From those at Dharmsala we seem warranted in believing that there were 1 or 2 gentle or preliminary tremors followed by a roar, and then by 2 or 3 severe shocks, the second of which was the most disastrous. People were thrown to the

[1] See Oldham, Mem. G. S. of I., Vol. XXIX, Chap. XIV.

x 2

ground, most buildings fell at once, but, as some think, at the second shock. The recorded directions of shock are, as was to be expected, extremely various; whilst from some statements the shocks can only be interpreted as a mass movement in a horizontal direction and back again—not so much a fierce shaking as a drag of the ground in one direction and then in another like the wash and back-wash of a water wave on shore. The very heavy mortality in the bazars, barracks and houses seems to imply the same thing, from the fact that only those who were warned by the preliminary tremors and by the sound had time to escape. All who waited for the shock itself were unable to get away. Consider the statements—"the houses lurched forward with violence and came down as if made of cards," and "in a moment, with two fearful lurches, every house collapsed" and the still more laconic "our houses fell down" and "the saheb had been thrown into a corner and killed" (see p. 27).

The absence in all this written evidence of any reference to shaking or vibration, and the insistence on the instantaneous character of the phenomenon confirms the conclusion drawn from the examination of the ruins and hillsides, that the principal shock was so severe that the complex of ridges and spurs were only able to take it up as one or two vigorous and largely horizontal lashes (after the first tremors were done) and that these horizontal lashes or rapid swayings were at once damped on all slopes by free movement and spreading out of soil-cap with surface fissures as already explained.

From one eye-witness at Dharmsala (see p. 17), there is some reason to believe that the necessarily slow translation of such surface movements was actually observed, and that the waves surged about the variously curved slopes of the hills upsetting bazars and buildings thereon, not simultaneously, but one after the other at intervals appreciable to the eye.[1]

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1 Mallet in his description of the great Neapolitan Earthquake found that the rocking of towns perched on the summits and flanks of hills, especially the lower spurs that skirt the great mountain range, greatly aggravated the natural effects of the shock.

Attention has just been drawn to the different effects of the shock on the spurs, ridges and hollows. But the comparative effects on different classes of buildings are also worthy of note. That the prevailing type of bazars built of sun-dried bricks and mud mortar would be severely damaged by any earthquake of considerable magnitude may be said to be almost a foregone conclusion, but there are other considerations which render such frail structures particularly unstable :—

Effects on buildings.

First.—The usually open verandahs.

Second.—The open fronts of the shops behind the verandahs, and only partially boarded in.

Third.—The floors of the second story resting on beams let into the mud walls.

Fourth.—The heavy slate roof.

Fifth.—The irregular mode of building shops of all sorts and sizes without plan or arrangement : a condition which made it impossible for any two neighbouring shops to swing together with like periods. Hence they mutually charged into and destroyed each other in their efforts to make independent swings.

It is doubtful whether many of the older private houses in Dharmsala were much superior to the bazars in their earthquake resisting powers. Certainly all having two stories and the consequent intermediate floor were equally ineffectual, because of the battering-ram like action of the beams and joists directly any rocking motion began. Even the strong stone buildings such as the Gurkha mess-house and old British barracks suffered inevitably from this horizontal line of cleavage at the upper floor.

On the other hand equally strongly built single-storied buildings such as the magazine, quarter-guard and treasury, without any lines of great weakness, and with a strong domed roof binding the walls together instead of lying loosely on them, successfully resisted the shocks by rocking as single masses.

It would have been interesting to compare with these the effects on pliable wooden or entirely bamboo structures with thatch roofs, but so far as I know there were none of this type in the station.

Until, and unless, earthquakes become a common occurrence instead of an isolated, hardly remembered catastrophe, it would, in the writer's opinion, be useless to urge the construction of earthquake-proof buildings. It would also be useless to discountenance building on ridges and spurs for the same reason. There are too many immediate advantages of economy and convenience to be derived from using the material that is close at hand, from following the styles of building familiar instead of strange, and from adopting any building site that is available and conveniently placed, to make it reasonable to use legislative action in restricting private enterprise to certain forms of structure and to certain localities. Whether the Government itself will think it wise to set an example by building its own offices on some earthquake-proof model or not, remains, so far as I know, to be as yet decided. If this should be determined on, the easily available supply of rounded river boulders from the neighbouring stream-beds should be utilized for foundations, on which a strongly keyed and framed house could move as it were on ball bearings.

Kangra.

Although we have no accounts of eye-witnesses from Kangra, there are certain observations of overturned objects (described at p. 35) which give us some details regarding the other wave elements of the shock at that place in addition to its mere intensity. The gate pillars and simple rectangular tombs in the Bhawan cemetery were found to yield the following values for the wave elements :—

Acceleration .	= 13 feet per second per second
Amplitude .	= $9\frac{3}{4}$ inches
Velocity .	$3\frac{1}{4}$ feet per second
Period. .	= $1\frac{4}{7}$ seconds

and it is probable that the Hindu temple *sikras* which were either overturned or in a leaning condition would give us much the same figures if their more complicated shape could be reduced to a simplified

form. The very large amplitude of 9¾ inches testifies to a highly destructive slow-moving wave similar to that which must have obtained at Dharmsala, and having as its physical reason the loosely aggregated sub-recent gravels, sands and clays and their numerous steep and high free edges at the river gorges. The acceleration of 13 feet per second per second is equal to 3,900 mm., which according to Omori is above scale X, coming near his own number 6. The overturned objects at Kangra yielded a more or less definite direction of overthrow within a limited area, namely, between N. 15°E. and N. 93°E.

Palampur neighbourhood.

At Clachnacuddin Tea Estate three shocks are reported, the second longer and more violent than the first and from N.E. or E., whilst the third is described as a sudden jerk from N.E. and back again. We have also data from the projection of the crosses from the gable-ends of the Palampur Church to distances of 21 feet 10 inches and 21 feet 3 inches from vertical heights of 37 and 46 feet respectively, which testify to the high swing acquired by the building during the shock.

In the two cases $v = \sqrt{206}$ feet and $\sqrt{204}$ feet per second, respectively, *i. e.*, about 14 feet per second, as the greatly magnified horizontal velocity with which they were jerked off their high positions.

Isoseist No. IX.

(1) Description and general intensity.

Boundaries less well defined than VIII or X.

This isoseismal line is not so well delineated as either VIII or X. It would indeed be sufficient if it were regarded merely as an interpolation between VIII and X. Still it encloses an area in the greatly disturbed tract that has many characteristics of its own. An attempt will now be made to summarise these. In extent it embraces an area of about 1,600 square miles, surrounding No. X in a rough ellipse. The greater part of this area lies to the east-south-east of the X area with only a comparatively narrow band continuing round its north-west part. On the west and south this isoseismal can be located with considerable accuracy as it cuts

Shahpur, Ranital and Sujanpur; but further east-south-east by Mandi and Manglaur it is less well defined, the destructive effects within it dying away very gradually in that direction just as was the case within isoseist X. Its northern course also is somewhat vague where it cuts the uninhabited and little-trodden snowy ridge of the Dhauladhar passing thence to the Beas valley between Sultanpur and Naggar.

As a whole it may be said to be the area of moderate destruction.

An area of moderate destruction.

But inasmuch as it includes a great variety of country ranging from the gently lying Kangra valley to the rugged mountains of Kulu which comprise varied styles of village architecture, the results show a similar diversity that is not easy to summarise in a word or two. Temple *sikras* as mentioned under the last sub-heading were not overthrown as shown by many examples at Mandi, Bajaura and Sultanpur, damage to them being entirely confined to the downthrow of the *amalaka*, or top ornamental stone (see pp. 50, 56, 58) or to small horizontal shiftings of the courses of masonry.

Variety of village architecture.

Great diversity in the styles of village architecture in this area has helped to complicate deductions concerning the apparent intensity. Only in the area of the Kangra valley was one able to compare effects within this isoseist on sun-dried brick and slate roofed bazars with those in the same class within isoseist No. X.

In the more eastern and hilly parts of this area a great feature in promoting the destruction of many buildings was the free use of river boulders in the construction of walls. At Mandi, Sultanpur and generally along the large river valleys, such material had been frequently employed by native builders, and it even found its way into the construction of the piers of the Buin suspension bridge, which was totally wrecked.

Another feature was the mixed and debased styles of building used in the bazars of Sultanpur and other parts of the valley, styles which involved the use of much wood in the construction of the walls, but without the advantage of a properly keyed and pegged wooden frame as in the old hill models. The latter in the form of dry stone and wood-

bonded towers, often built *kat-ki-kuni*, seemed to have generally stood well both in the IX and VIII areas, damage only appearing where the timbers had manifestly rotted.

Large numbers of cattle are said to have perished in parts of this area, *e.g.*, Mandi and Suket, owing to the custom of sheltering them in the lowest stories of the houses. In other parts many perished in caves and by being overwhelmed in rock avalanches. The heavier Mandi slates, which are much thicker than those got near Dharmsala, would have contributed no doubt to the destruction of houses more than they did had it not been for the freer use of better and stouter timbers in the roof.

Bungalows.

Of the bungalows set apart for travellers nearly all showed fairly well the average and moderate damage of this area, which fell far short of complete destruction except in the case of one or two of ancient and poor construction, *e.g.*, Jhatingri and Kataula. The majority were being repaired as they stood by partial renewal of portions of the walls, roofs, etc. In rare cases, such as at Shahpur, one could still use a room or verandah, at a pinch, whilst well-built private bungalows and native houses at Bajaura, Mandi and Jhatingri still remained quite habitable though much rent and fissured.

Although the travellers' bungalows differ among themselves a good deal, they are perhaps the most uniform of any buildings for comparison. It will be remembered that all such were ruined within area X. Within the present isoseist No. IX we may tabulate the results as follows :—

Travellers' bungalow at	Summary of damage done.
Shahpur . . .	Single storied, partly of dressed stone and brick set in mud mortar. Slate roof on iron rafters. It was badly rent, chimneys fell, end walls just did not fall.
Ranital . . .	Double storied building. Badly rent, portions of upper walls ruined.
Jawalamukhi . .	Equal to Shahpur or Ranital.
Baijnath . . .	Badly rent and fissured, worse than Shahpur, not so bad as Ranital.
Dhelu . . .	Chimneys fell, bungalow still standing, rent and fissured.

Travellers' bungalow at	Summary of damage done.
Jhatingri . . .	Old and very badly built of fragments of undressed slate and mud mortar. Ruined, outhouses destroyed.
Urla . .	Built of rough stone slabs, etc., fitted together without any mortar or mud cement and with wooden beams laid horizontally among the stones at intervals Chimney fell, damage equals Shahpur.
Mandi . . .	Chimney standing though much damaged. Roof buckled in places.
Kataula . . .	Old and badly built of slate fragments roughly fitted together without any mortar. Destroyed all but one corner.
Kandi. . . .	Equal to Shahpur. Cross walls fractured and plaster had fallen.
Bajaura . . .	Partly built of sun-dried bricks and flat blocks of stone. Half ruined, was being repaired as it stood.
Sultanpur . . .	Partly ruined but not so much as Bajaura, was being repaired as it stood.
Larji	Seriously damaged and not weather proof. Verandah could be used.

Landslides and dust clouds.

The area includes much high ground such as the culminating ridge of the Dhauladhar lying to the north of the Kangra valley which were characterised, especially near the snow line, by many terrific landslides with occasional dust cloud phenomena as detailed at page 42. The steep slopes in the Parbati R. and those near Larji in the valley of the Beas also fall within this isoseist and were localities that were also the scene of landslips of great size and occasional dust clouds. They also included the temporary formation of two lakes in the Tirthan and Sainj gorges by landslip dams. Considering the magnitude of these surface displacements of rock and soilcap within isoseist IX, one may freely conjecture how disastrous the results might have been to those colossal slopes (many of which approach or even exceed the limiting angle of stability in such rocks) had they fallen within the next highest isoseist, No. X, instead of only within that of IX.

The area also includes the Guma and Drang salt mines and the much smashed and powdered rocks in the vicinity of the main boundary fault from which many landslips descended choking the open workings.

It also includes the Bubu and Dulchi passes, the former of which was seriously blocked for months, and the latter considerably injured by falls of the bridle track. It has been noticed that many springs were affected in this area, such as those near Jawalamukhi, although this is not a character particularly appertaining to this isoseist. Damage to hill roads within this isoseist was frequently very severe, especially in the case of the new cart road north of Mandi and the bridle roads along the Beas, at steep places such as Larji. In connection with roads two important bridges at least were demolished, one by landslips at Barwar lake, and the other by disintegration (Buin).

As before, the general direction taken by isoseist IX can be seen by the map. The principal towns included within it are given below :—

Geographical Index.

Places between Isoseists Nos. IX and X.

Name of town or village.	District.	Lat. N.—Long. E.	Distance in miles from nearest point of main epicentre.
Baijnath . . .	Kangra . .	32°3′—76°42′	About 4
Bajaura . .	Do. . .	31°51′—77°13′	„ 10
Barwar (lake) . .	Mandi . .	31°42′—77°19′	„ 17
Bhuin . . .	Kangra . .	31°53′—77°13′	„ 9
Bubu (pass) . .	Do. . .	31°57′—77°3′	„ 6
Dhelu . . .	Mandi . .	32°0′—76°51′	„ 4
Drang . . .	Do. . .	31°49—77°1′	„ 4
Dulchi (pass) . .	Do. . .	31°5″ 77°9′	„ 5
Guma . . .	Do. . .	31°58′—76°55′	„ 4
Jhatingri . . .	Mandi . .	31°57′ 76°57′	„ 3
Kohad . . .	Kangra . .	32°5′—76°52′	„ 9
Larji . . .	Do. . .	31°14′ 77°17′	„ 14
Mandi . . .	Mandi . .	31°42′ 77°0′	„ 10
Paprola . . .	Kangra . .	32°3′—76°42′	„ 4
Ranital . . .	Do. . .	32°1′ 76°18′	„ 10
Shahpur . .	Do. . .	32°12′—76°15	„ 8
Sujanpur . . .	Do. . .	31°50′ 76°33′	„ 14
Sultanpur. . .	Do. .	31°57′—77°10′	„ 10
Swar . . .	Do. . .	32°5′ 76°55″	„ 11

(2) Character of the Shock.

The following are all the facts and impressions I have been able to gather concerning the character of the shock within area IX.

Baijnath : Drang.

From Baijnath the shock is described by one observer as lasting 3 to 5 seconds and without any preliminary tremors, whilst by another it is described as all one huge vibration, increasing gradually in intensity until he was nearly thrown off his feet. The ground is stated to have been apparently moving in waves and that trees swayed with terrific force to within a few feet of the ground, whilst puffs of dust, marking falling villages, progressed from south to north. The sound, which was a roar like a gale approaching, occurred 5 seconds before the shock began. The last description seems to bear the stamp of careful analysis, whilst both agree that there was but one movement. The same point is brought out in the evidence furnished from Drang and Mandi, but from the last place the quake is represented as 3 almost successive shocks, the direction being N.W.—S.E. and preceded by a booming noise.

Bajaura.

From Bajaura the evidence of one observer familiar with earthquakes testifies to there being but one single accelerating motion increasing in violence to a maximum and then dying down, the duration being 1¼ minutes taken by a stop watch. The direction is doubtful, for whilst one observer gives it as N.—S. another equally credible gives it as E.—W. (from which it is probable that the direction changed during the progress of the shock). One observer states that the quivering motion of the ground was so irregular that objects not only shook sideways but also danced up and down like a bubble of water on a hot plate. It was very difficult to stand during the more violent phase. The sound, which was a dull rolling becoming like a cannonade, began 10 seconds before the shock.

Conclusion for the Kangra-Kulu area.

The above practically concludes the statements and deductions for the Kangra-Kulu epicentral area between the X and IX isoseists, and from them one or two points seem to emerge which seem reasonable and congruous with other conclusions regarding the earthquake. It seems clear that as we proceed from Dharmsala in an E.S.E. direction the character of the earthquake

changes from one characterised by a preliminary tremor or tremors followed by a sudden thrust or thrusts backward and forward that instantly destroyed all buildings, as at Dharmsala, to one that was a regularly increasing single-movement vibration and much less destructive. The line of change corresponds to the passage from the Upper Siwalik conglomerates and soft sandstones to harder and firmer formations until at Bajaura we are on the much more compacted old Himalayan series, and it also corresponds, as we shall see later, to what is deduced as the direction in which the axial centrum "pitches" or increases in depth.

Isoseist No. VIII.

Relatively well-marked in two closed curves.

The VIIIth isoseist is relatively a very well-marked one. It forms two separate closed curves, one in the Kangra-Kulu area and the other, a smaller one, in the Dehra Dun-Mussoorie area. In both areas, but especially in the main Kangra-Kulu area, the VIIIth isoseismal is the boundary where sensible damage to buildings begins to be plainly visible. On entering that area the least observant of human beings would very soon have seen that a disaster had occurred, whereas, avoiding the larger towns, he might have wandered over the surrounding isoseismal zones for days without encountering anything more noticeable than a few tiny cracks in walls.

(1) Kangra-Kulu area.

Position and included area.

Like the other isoseists, this isoseist is more definite in position in a W.N.W. than in an E.S.E. direction. The curve cuts Telokenath (Mangla Devi) near Kotla, a point between Dera Gopipur and Jawalamukhi, Suket and Rampur; whilst in its northern curve it cuts less definitely a point between Naggar and Manali, another a little east of Manikarn and a third at Gaora near Rampur. The included area is about 2,150 sq. miles, and it forms an elliptical belt round the IXth isoseist. To the north of the Dhauladhar

ridge this belt is somewhat vaguely known, but a few observations on the villages in that neighbourhood were made by Colonel Hayes, 1st Lancers (see p. 75). On the west and south-west I have myself in the previous chapters described the area in the vicinity of Haripur and Dera Gopipur (see p. 38) and similarly with regard to the neighbourhood of Naggar; whilst higher up the valley, at Manali, notes by Captain Banon furnish us with sufficient data. Among other things the latter drew attention to a peculiar effect in this area, namely, the snow mist that resulted from the vast number of avalanches of snow detached from the steeper slopes by the earthquake (p. 75). The Malana glen and the upper reaches of the Parbati between Jari and Manikarn give instances of the extension into this VIII area of damage to the hillsides due to their precipitous nature and to the splintery condition of the rocks. In like manner both here and near Manali springs of water were affected. The area lying south-east of the Barwar lake as far as Kot on the south side of the Jalori pass has been described (p. 72), whilst that near Suket was reported on by Mr. Burkill (see p. 76). From the above with the aid of a map it will be seen that this rather large isoseist, which sometimes passes into out-of-the-way valleys has been fairly examined along 6 or 7 cross-sections, sufficient to delineate it with all necessary accuracy.

Damage to villages.

The damage to the villages in this area was what one may generally call slight. It took the form of a roof gone here, the end house of a row there, a hill tower bulged or partially shattered and so on, the damage being everywhere easily appreciable by the eye, but generally mild enough for the inhabitants to still retain possession of their homes after a little patching had been done.

Damage to bungalows.

Of travellers' bungalows within this isoseismal nearly all were habitable in parts, and many private bungalows such as some of the more better built modern ones at Naggar were scarcely damaged at all, or only in their upper stories. Others more heavily built and of greater age had been badly shaken and fis-

sured, but none were in ruins. Summarising the damage to travellers' bungalows within this VIIIth isoseist we have :—

Travellers' bungalow at	Summary of damage done.
Jari .	Intact and habitable.
Manikarn	Ditto.
Manglaur	Not much damaged, some rooms habitable.
Jibhi .	Built *kat-ki-kuni*. Intact save roof near chimney and verandah of heavy slate out of plumb.
Kot .	Timber bonded but not *kat-ki-kuni*. Walls bulged. heavy slate roof damaged and had been removed since the shock.

Damage to bungalows just outside VIII area.

For the purpose of the better circumscribing the VIII area we may here give for comparison a summary of damage done to travellers' bungalows in the parts of the VII area immediately surrounding the VIII area in these hilly tracts :—

Travellers' bungalow at	Summary of damage done.
Pathankot . . .	Uninjured.
Nurpur . . .	Just visible cracks at joints of walls.
Dera Gopipur . .	A few minute cracks in plaster of corners, etc.
Chawai . . .	Habitable, only chimneys fell.
Dalash . . .	Intact, even chimneys in position: a few tiles loosened and fine cracks in plaster of walls.
Luri	A well-built modern bungalow. No cracks at all.
Luri to Simla . .	All bungalows intact.

If we were to consider only the evidence supplied by the travellers' bungalows for the areas circumscribed by the Xth, IXth, and VIIIth isoseists together with that in the VII area just outside VIII, I think such data alone would be sufficient for drawing the isoseists as they have been drawn in conformity with the Rossi-Forel scale of intensity (see p. 302)

(2) The Dehra Dun-Mussoorie area.

No doubt about its detached position.

The smaller closed curve of the VIIIth isoseist is not perhaps so sharply marked off as that in the Kangra-Kulu area. But there is no doubt from Messrs. Simpson and Hallowes' work and from the numerous earthquake forms relating to that part that such an area exists round about Dehra Dun and Mussoorie, and that it is entirely detached from the larger Kangra-Kulu curve. In my preliminary report I regarded the above as a nearly established fact, but had to admit that the hilly tract directly in line between Rampur on the Sutlej River and Mussoorie or Chakrata had not been personally visited. Since then, however, my colleague Mr. Hayden traversed across this line east from Kotgarh and was able to confirm the absence of visible earthquake effects along that line. See also Mr. Tendall's earthquake form from Rohru, Simla District (p. 181).

We are now therefore certain as to the complete separation of the Dehra Dun-Mussoorie VIIIth isoseist from the same isoseist in the Kangra-Kulu area. Also, from Messrs. Simpson and Hallowes' work we may be equally certain that in spite of many visible records of the shock in the form of cracks and displacements in masonry buildings in the important towns of Saharanpur, Rurki and Hardwar, these towns have suffered much less than Dehra Dun, Mussoorie or Landour, and therefore that the VIII area is equally bounded in the opposite direction towards the plains. All that remains slightly problematical is the precise position of the curve—the line as drawn may be perhaps a few miles out on either side.

The following index shows the places within the VIIIth isoseist in the two areas.

Places between Isoseists Nos. VIII and IX.

(1) Kangra-Kulu area.

Name of town or village.	District.	Lat. N.—Long. E.	Distance in miles from nearest point of main epicentre.
Banjar .	Kangra	31°38′—77°24′	About 24
Hamirpur	Do.	31°41′—76°35′	„ 22
Jalori (pass)	Do.	31°32′—77°27′	„ 30

Places between Isoseists Nos. VIII and IX—concld.

(1) *Kangra Kulu area*—concld.

Name of town or village.	District.	Lat. N.—Long. E.	Distance in miles from nearest point of main epicentre.
Jari	Kangra . .	32° 0'—77°18'	About 18
Jawalamukhi . . .	Do. . .	31°52'—76°23'	„ 16
Jibhi	Do. . .	31°36'—77° 5'	„ 26
Kot . . .	Do. . .	31°31'—77°29'	„ 33
Manglaur . . .	Do. . .	31°40'—77°22'	„ 21
Manikarn . . .	Do. . .	32° 2'—77°25'	„ 24
Nadaun	Do. . .	31°47'—76°24'	„ 21
Naggar	Do. . .	32° 7'—77°14'	„ 20
Plach	Do. . .	31°39'—77°24'	„ 23
Suket	Suket . .	31°32'—76°58'	„ 22
Telokenath . . .	Kangra . .	32°14'—76° 8'	„ 14

(2) *In Dehra Dun-Mussoorie area.*

Name of town or village.	District.	Lat. N.—Long. E.	Distance in miles from epicentre.
Chakrata . . .	Dehra Dun .	30°43'—77°54'	All within a few miles.
Dehra Dun . . .	Do. . .	30°19'—78°5'	
Landour	Do. . .	30°27'—78°7'	
Mussoorie . . .	Do. . .	30°27'—78°2'	
Rajpur	Do. . .	30°24'—78°5'	

Character of the Shock.

(1) *Kangra-Kulu area.*

No accounts have come in from the VIII area in the Kangra-Kulu tract, nor were there any other special facts observed from which any deductions regarding the character of the shock might be drawn; there being no large towns to furnish any data regarding the wave elements other than the general intensity of the shock.

(2) *Dehra Dun-Mussoorie Epicentral area.*

In spite of a certain amount of contradiction in the descriptions of the shock from this area, we gain a very fairly complete idea of its

character from the many excellent reports sent in from this well populated region. The distinctly vibratory character of the shock is everywhere admitted.

Preliminary vibrations.

That there were mild preliminary vibrations is testified to by a large number of observers, and such have been characteristically described as quiverings, like palpitation of the heart or like a dog scratching himself under the bed (the latter simile re-appears constantly in the descriptions). They appear to have lasted for from 3 to 15 seconds.

Principal shocks.

There was then a pause, some say of 2 seconds (but others place it as longer) and then followed 2 or 3 violent oscillations or groups of stronger and larger vibrations. Some put these as in very rapid succession, others give 2 or 3 seconds interval between them, the whole lasting 1 or 2 minutes. Where the principal shocks are mentioned as 2 in number, sometimes the first and sometimes the second is regarded as the more severe. The general opinion is that they came from N. to S. or *vice versâ*. The following are among the more characteristic descriptions of the main shock or shocks.

(1) All sleepers were awakened.

(2) Motion like a machine sieve worked by an engine.

(3) Like a steamer dropping anchor.

(4) Complete period of each vibration $\frac{1}{4}$ to $\frac{1}{2}$ second.

(5) Violent lateral vibrations at 4 to the second.

(6) Like strokes of a piston, 150-180 to the minute, as tested by watch afterwards.

(7) An irregular motion, the observer being jerked from side to side and then all round for 1 minute.

(8) As if taken by the shoulders and shaken violently.

(9) Many were unable to stand or walk properly. Enormous trees swayed. Tents lashed as in a gale.

(10) A large number of small objects, *e.g.*, bottles, glasses, vases, chimney-pots, Indian clubs, a few ornaments and crosses from tombs upset, pendulum clocks stopped, lamps and pictures swung.

The accompanying sounds were generally heard before and during the shock and were of the nature of rushing wind or a railway train in motion. Many agree that the shocks died away gradually as they had begun.

Conclusion.

It is clear from the above that either a continuous series of vibrations with distinct maxima and minima, or a preliminary set of milder, followed by 2 or 3 separate sets of stronger vibrations which died away, represent the case for this area. The variations recorded in detail may be either subjective, or have resulted from the diverse surface conditions.

Overturned objects.

A few overturned objects noted by Mr. Simpson give us certain information regarding the wave elements at this place. They are as follows:—In Dehra Dun cantonment 3 chimneys of the Imperial Cadet Corps new quarters, measuring 3 feet by 3 feet by 10 feet were not overturned though cracked at the base. From West's formula $f=g\frac{x}{y}$ already used (see p. 35) the acceleration of the wave particle cannot have been as great as 9 feet per second. But at Rajpur (a short distance away) one of two gate pillars, 22 inches by 22 inches by 8 feet was overturned. Using the above formula again we get $f=7$ feet per second per second, and as one was overturned and the other not, it is likely that the value 7 is about correct. In millimetres this gives 2,100 which according to Omori, is equivalent to Rossi Forel scale IX.

At Landour in No. 7 Barracks 20 chimneys 20 inches square by 7 feet high were fractured at the base and one was leaning. This gives $f=$ less than 11 feet per second. At Prospect Point a looking-glass at a height of 4 feet 6 inches on a wall was projected 3 feet 6 inches horizontally, which gives $v=6\frac{1}{2}$ feet per second as the horizontal velocity with which it left the wall.

Isoseists Nos. VI-VII, IV-V and II-III.

Only shown on the Indian side.

The area circumscribed within the two grouped isoseists VI-VII and those of all that follow are only shown on the west, south and east of the epicentral tracts, inasmuch as

the region to the north is generally inaccessible and uninhabited. These areas (although for the above reason they cannot be fully computed) are of immense and increasing size—the length of the VI-VII area along its longest axis being somewhat over 500 miles and spreading away from the hills into the great plains of the Indo-Gangetic drainage system.

On one of the maps (pl. 29) the VIIth isoseist is marked separately, and it is shown as taking a somewhat uneven course. This course is chiefly dependent on the relative values of the intensities as given by Mr. Pascoe in his descriptive part of this volume, the intensity at Lahore being taken as VII.

Drawn with smooth curves.

Outside of this area, with only the earthquake forms to depend on for evidence, the curves of the grouped isoseists have had to be made smooth, as representing a mean of many somewhat conflicting data. The data alluded to are of course the values of the intensities estimated for any particular locality on the evidence of the earthquake forms (see p. 303). Any other mode of drawing these lower isoseists would have led to extremely complicated curves, frequently approaching or even cutting one another, whose irregularities one would have known were far more the result of varying standards of observation than of any real surface difference.

With the map before one it is hardly necessary to describe the position of these curves in terms of the towns cut by them, or to give any further detailed lists of towns included within them. All the particular evidence for individual places is summarised in the previous parts of this volume, namely in the chapters devoted to Mr. Pascoe's survey and in that given in the earthquake forms. To these one must turn for all special information, which also has much of individual interest.

Brief treatment here.

But it is felt that only a very brief summarised description of those isoseismals as definite unit areas will be advisable here, seeing that their boundaries and contained areas, except in one case, were never personally surveyed, and are

therefore mere simple transcriptions of the intensity values allotted to the accounts in the earthquake forms.

VI—VII isoseist: apparent great damage.

In the area circumscribed by isoseist VI—VII, much of which was examined by Mr. Pascoe, the damage to buildings as has already been stated would at first sight appear to warrant a somewhat higher intensity number than has been allotted to it. It may be that some individual cases, such as the Town Hall, Lahore, are explained by the top-heavy construction of the building, others by some other peculiarity dependent on the diverse architectural styles found in a large city. But mostly it may be said that the large number of injured buildings in the big cities and towns of this region extending from Sialkote to Meerut are the direct result of the large size of many of them compared with those met with in the epicentral tracts. Where there are many buildings to damage, the laws of chance provide naturally a larger number so damaged.

Thus, commensurate with the vast areas embraced within isoseists VI—VII there is a high total of damage and pecuniary loss to the community as a whole, although the loss per unit house would probably be the same as in those other parts of the VI—VII area which I have described as being practically free from damage. In the case of some apparently well-built structures that have partly come to grief, we have also to balance against them, the large number of absolutely undamaged ones, in spite of the fact that (as in the case of the New Law Courts, Lahore) they presented fragile and delicate parts that seemingly might well have been shattered by the shock. (See pl. 19.)

Character of the shock, VI—VII area.

The character of the shock within this large area is difficult to summarise. The greater the area the greater the chance of variations and anomalies not only of fact but of description by the contributors to the earthquake forms. But, we may note that the shock has now lost very much of its fierceness. After generally noted preliminary tremors we have it described as sharp and jerky in a few places, or as a "prolonged steady reciprocating motion of horizontal jerks." But by far the larger number of description are

content with speaking of it as 1, 2 or 3 strong sets of vibrations, whilst the sound, no longer a roar or like a gale of wind, is far more commonly described as a rumble like thunder or surf, or a rattling noise like a railway train. One noticeable feature with regard to the sound is that none at all is recorded from Lahore, and a large number of observers state that there was no sound. I am unable to explain this except by the suggestion that the sound was mistaken for the ordinary rumble of street traffic.

Undulose waves.

Another peculiarity is that in addition to the quicker vibrations which one observer puts at 200 a minute, we have a great deal of evidence from many towns such as Pathankot, Hoshiarpur, Amritsar, Sialkot, Jamu, Ludhiana, Rurki and Meerut of a slow rolling or undulating motion described as "like being on board a steamer in a moderate sea," "like an open boat at sea," "the whole ground heaved like the sea and houses rocked," "caused tress to rock and dance as in a high wind." This motion made it difficult for the observers to keep their balance without legs wide apart and in some cases produced nausea and giddiness, and made animals restless and restive. These waves were accompanied also by fissures in the alluvium through which sand and water in fountains spurted, as at Rurki and Karnal.

The Himalayan areas of Kashmir and Garhwal and Kumaun, with the exception of Islamabad which is in a flat plain, generally did not experience these long slow undulations, which seem to have been more typical of places on the thick Indo-Gangetic alluvium. But Simla according to a correspondent of the *Statesman* experienced a similar but somewhat quicker type of undulation (see page 75).

The above appear largely to have been characteristic gravitational waves, and entirely without the strong lateral thrusts as experienced at Dharmsala and elsewhere within area X, and spoken of as "fearful lurches." One observer at Ludhiana, however, speaks of a "push of thrust" in a westerly direction with intermediate violent vibrations too rapid to count, as if the house were a "box shaken by giant hands." But this is a very exceptional description for this area.

Of overthrown bodies recorded by Mr. Pascoe we have a certain number from which a limiting high value for v may be deduced. From projected brick globes on the Town Hall, Lahore, in its higher part, we have a horizontal distance of 32 feet and a vertical one of 67 feet which gives $v=16$ feet per second. From those on the lower part of the same building we have horizontal projections of 17 and 15 feet respectively, from a height of 56 feet which gives values for $v=9$ and 8 feet per second respectively. Other calculations made by Mr. Pascoe are, for Lahore—iron flag on railway station roof $v=6\frac{1}{2}$ feet per second, cupolas of Golden Mosque $v=6{\cdot}91$ and 5·35 feet per second, and for Sialkot, cross from steeple of church 169 feet high $v=12{\cdot}7$ feet per second, v representing in all these cases the maximum horizontal velocity with which they were projected from their high positions. Mr. Pascoe comments on the fact that of several tall factory chimneys near the railway line at Lahore none had fallen. The same immunity was also remarked by me with respect to the Dhariwal mill chimneys.

Projected bodies.

With the IV—V area we arrive in the region of no damage at all, not even cracks, except in a few cases of particularly dilapidated and ancient edifices. There is small wonder at this when we consider the enormously extended front of the surface wave over which all the energy of the original seismic disturbance has now to be distributed. That known surface front at the IV—V isoseist is about 1,200 miles, and there must have been a front equally long on the Tibetan side of the seismic area. It is also the region of no overturned objects, and also where panic in the case of the able-bodied is almost conspicuous by its absence. It is primarily the area of tremulous vibrations which nevertheless in many cases are still differentiated into preliminary tremors, main shock and end tremors. It is the area of rocking beds—"like a dog under the bed" and swinging punkahs, and rattling doors and windows. Occasionally trees are stated still to rock and a rolling motion of the ground is still felt but not so markedly as in the VI—VII area. One observer has described the sensation as that of a swing going dead slow. The sound is of the usual

Character of the shock, IV—V area.

rumbling kind when heard, but it is very frequently not heard at all. As an exception to the above, from one hilly area, namely, Abbottabad in Hazara, the motion is described as much rougher, being like a springless cart with loose axles : a succession of bumps and jars, and a hanging lamp is said to have shown evidence of much vertical motion. This is somewhat difficult to understand so far away from the seismic centre.

Isoseist II—III, want of details in the reports.

The vast region embraced by the outermost isoseist II—III is also somewhat difficult to summarise. In the earthquake forms one may read that the shock was not felt or that it was almost imperceptible, side by side with descriptions of it as a big shock. Of far more importance, however, in gauging the intensity of an earthquake from written statements, is the amount of detail in them. Now one characteristic of most of the forms from this area is the want of details, or when such do occur they have reference to movements of water in tanks or the gentle swaying of suspended objects, occasionally also of beds, doors, creaking of rafters and such like. The following are of some interest :—As far away as False Point in Bengal the look-out man above in the lighthouse felt the shock and the lightning conductor swayed. In Midnapur (also in Bengal) the nature of the shock was at once understood from the movements of tank water, and the people blew conches. The shock is also described from Chapra as frightening birds in aviaries. The bubble movements in level tubes reported from Tando Masti Khan in the Khairpur State, Sind (see p. 252) and also from Thedaw in the Meiktila District, Burma (see p. 270) are of great interest, and may be referred to here, although the latter place is altogether out of the felt area.

Character of the shock.

We may, I think, be certain that there was no violent shock in this area, that there was no savage shaking such as has been described in the Mussoorie area, no rapid vibrations, or visible undulations such as are commonly eported from the VI—VII area, no disturbances of furniture and loose objects, no general awakening, no panic, no stopping of clocks, except one electric clock in Calcutta, nor was it even generally felt by everyone

as in the IV—V area. No sound has been generally recorded except from certain localities in Assam and Eastern Bengal where it is probable the shocks were of local origin and had nothing to do with the Kangra earthquake. In spite of local variety in estimating this shock I think we may say as a whole that the shock was hardly felt and not generally felt except by people in favourable situations, and that it was frequently only deduced from movements of bodies of water and other delicately poised or suspended articles.

Notwithstanding its feeble character and its still more extended front which must have reached four times the value given in the last area before it was utterly lost to human sensibility, it is worth noting that it became violently destructive at one place, namely, Ahmedabad, where three 13½ inch masonry partitions in water-supply tanks fell to the south owing to the height of the water being raised on the north side first as the wave passed under them. (See p. 250.)

III.—NATURE OF FOCUS : DEPTH, ETC.

No evidence for a complex near-the-surface origin as a net-work or branch-work of faults.

On account of the tendency recently exhibited in the writings of certain authors to view tectonic quakes of great violence as due to a net-work or branch-work of faults, not necessarily very deep in origin, and frequently attested and indicated by actual surface fissures,[1] it may come as a surprise to many to be assured that the Kangra earthquake presents no evidence at all in support of this view : not a single railway has recorded any damage to the track, not a single road or path has been deflected, raised or lowered, no rivers or streams have changed their courses or been temporarily dammed up—except as due directly to landslips from slopes of such great steepness that they might as easily have occurred after a heavy torrential rain-storm. It is true there are no railways in the main

[1] Harboo—Erdbeben Linien (Beitäge zur Geophysik, V. p. 206.) See also :—
Hobbs—On some principles of Seismic Geology (Beiträge zur Geophysik, VIII, 2, 1907).

epicentral area, although numerous enough between isoseismals VII and VIII, but the excellent cart roads that permeate the Kangra valley and Debra Dun are so common that it is inconceivable that any real fault scarp or fissure with appreciable movement along vertical lines could have remained unnoticed and unreported on, even if such had perchance escaped the observation of the special officers who personally examined the areas.

All fissures in this earthquake secondary.

There can be no doubt, I think, that the surface fissures in alluvium and soil cap which have been recorded in the descriptive chapters of this memoir, are without exception a simple result of the shaking which such a mountainous area received by the earthquake, and no more point to deep-seated fissures than do house cracks.

Surface intensity evenly distributed.

In illustration of the same conclusion it may be further insisted on that the most intensely disturbed area lying within isoseismal X, as also that within isoseismals VIII and IX, everywhere show a full and uniform measure of damage spread evenly over the areas in question. They are entirely without any tendency to lineally arranged series, at right angles to which damage rapidly diminishes. Besides my own personal investigation, the reports of the Punjab Government are quite clear on this point, a point also which is the more convincing when it is remembered that the Kangra valley villages are not concentrated centres of grouped streets, but widely diffused hamlets and homesteads whose outskirts mingle. The descriptive accounts in the preceding chapter devoted to the isoseismals can only be understood in this sense.

Conclusion against the complex, near the surface origin.

From this point of view therefore the area of maximum intensity cannot be regarded as a net-work or branching system of near-the-surface fractures, and much less can the outer areas of less intense destruction be similarly regarded as due to extended branches from any central net-work or branch cluster. As already explained

the time evidence which might have yielded data in this connection is too unreliable in the more central region to afford any basis for argument whilst outside that area it is distinctly at variance with the theory.

Depth of origin probably considerable, and shape simple.

It is therefore probable that the origin of the Kangra earthquake was at some considerable depth, and of comparatively simple shape, a conclusion reached also by other reasonings from the area of most rapidly diminishing surface intensity as illustrated by the isoseists.[1] This line of argument was given in my preliminary report in the "Records," and, after carefully considering it again, I am still of opinion that it represents as nearly as possible the actual state of affairs and requires no modification owing to more complete knowledge. It therefore may be repeated here.

Further considerations based on disposition of the isoseists.

We may note the following already established peculiarities about the isoseismal lines :—

(1) The elongated epicentral tract enclosed within the last 3 isoseismals of highest intensity in the Kangra-Kulu area.

(2) The close approximation of their curves at the west-north-west end of that tract.

(3) Their widely-separated positions in an opposite direction, *viz.*, east-south-east.

(4) The small, isolated ellipse forming the southern part of isoseismal No. 8 in its course round the Mussoorie area.

With regard to (1) the elongated form of the Kangra-Kulu epicentral tract, it seems certainly to indicate that the original earthquake impulse proceeded from a centrum of the nature of a line or plane following beneath this longitudinally extended tract.

1 The earthquake shadows and other minor irregularities manifestly due to "bays," the hills do not affect this conclusion.

With regard to (2), it should be remarked that in travelling from Nurpur to Kangra, and from Haripur or Dera-Gopipur to Kangra, we cross in each instance through the grades of intensities from such as are marked by trivial cracks in the plaster and corners of walls to those of complete destruction to buildings, and all within the short radial distance of 8 or 9 miles. In other words, the surface intensity increases extremely rapidly in these directions and indicates a proportionately shallow depth for the position of the centrum in the vicinity.

With regard to (3)—which briefly expresses the fact that in travelling from the Kangra neighbourhood across the same isoseismals but in an east-south-east direction we must cover about 100 miles of continuous and slightly diminishing intensity—an exactly opposite conclusion is indicated, namely, the increasing depth of the centrum in that direction.

With regard to (1), the conditions imply a smaller separate centrum following an axis parallel to that of the Kangra-Kulu area, once more rather nearer the surface, and of an actual intensity at the focus much less than that at the Kangra-Kulu centrum.

For the present we must be content to regard these two axial lines lying within planes (probably of faulting), as being the main and subsidiary loci either of one universal and contemporaneous shock, or of two, or even a series, of separate but almost instantaneous shocks, following one another sympathetically along lines of great tension.

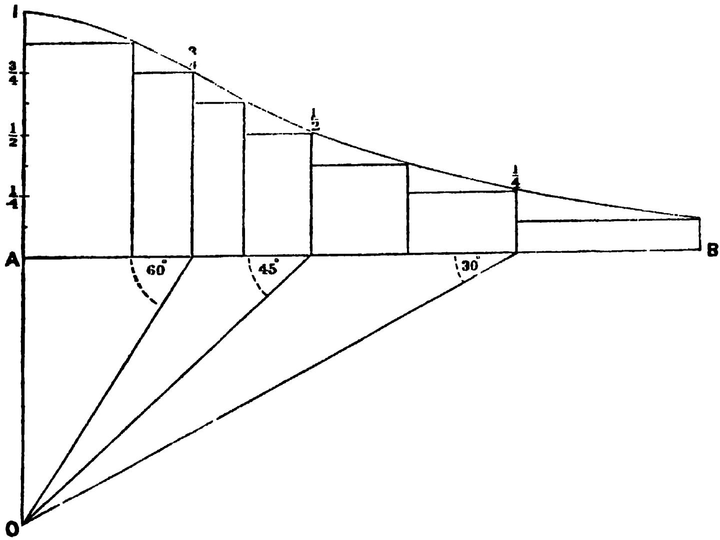
Depth of centrum: approximate quantitative determination: Dutton's method.

To calculate approximately the depth of the focus, the method adopted by Major C. E. Dutton [1] recommends itself here by its reasonableness and general applicability

On the assumption of a uniform medium, and that the intensity varied inversely as the square of the distance from the origin, Dutton shows that the variation of *surface* intensity along a horizontal line

[1] "Earthquakes in the light of the New Seismology," Chap. IX (1904).

drawn from the epicentre, is most rapid at a particular point which depends on the depth of the focus only, a point also where the intensity must be ¾ of the maximum intensity at the epicentre. The relation between the two is exhibited by the formula $x = q \tan 30°$, where x is the horizontal distance of the place from the epicentre, and q the depth of the focus. If x is known, then $q = x\sqrt{3}$. In the diagram, fig. 45, A B represents the surface of the ground. O the centrum, and the vertical lines are proportional to the intensities at the several points on A B. The resulting curve is steepest at the point where it touches the ¾ intensity line.



Fig

Now, it seems that we may apply this formula to the present earthquake by making sections across the epicentral tract at right angles to its

long axis. The only difficulty is the recognising of that portion of the cross-section where the intensity declines or varies most rapidly. With regard to the Kangra end of the northern epicentral tract, there is no difficulty, as has already been shown, in making a selection of points situated near its W.N.W. end which must be correct within a few miles. From those points the distance to the epicentral line cannot be less than 7 or more than 12 miles. The centre, therefore, between Kangra and Dharmsala must lie at some depth greater than $7\sqrt{3}$ and less than $12\sqrt{3}$ miles, *i.e.*, between about 12 and 21 miles. Taking another cross-section over the tract from Naggar through Sultanpur, Mandi, and Suket, the horizontal measurements, though less exact, cannot be less than 12 or greater than 24 miles, and therefore the depth must lie between $12\sqrt{3}$ and $24\sqrt{3}$, or between 21 and 40 miles.

Pitch of centrum.

The centrum thus deduced for this part of the earthquake-area can, therefore, be represented by a line or axis running from a point about midway between Kangra and Dharmsala in an E.S.E. direction towards Bajaura, a distance horizontally of 50 miles and at a depth of from $>12<21$ to $>21<40$ miles, the average being from 16 to about 20 miles, with a dip or pitch of 13½ degrees with the horizontal.

It will no doubt be thought by many that the above depths are possibly exaggerated, and in any case there is no doubt about their vagueness. Whilst freely admitting the possibility of serious refraction caused by change of rock-formation through which the shock must have been propagated, there are two general facts which point to at least a *considerable* depth for the part of the centrum below the Kulu area. One is the extremely large area over which the shock has undoubtedly been felt, and the other the only moderate violence at the surface. In other words, a shock of intensity 8 at the surface at Kulu, if of shallow origin, would not have been so powerful at that origin as to have been felt in such remote parts as the Bombay Presidency and Assam, nor would one of intensity 10 at Kangra unless it also were proportionately deep-seated.

With regard to the smaller subsidiary focus for the isolated Dehra-Mussoorie area, the fact that the latter is delineated by only one isoseismal, which has only been crossed by my colleagues at one point of its southern limb, and at a time when its isolation from the Kangra-Kulu epicentral tract was not suspected, renders impossible the application of Dutton's method of estimating the depth, inasmuch as there are no data for approximately determining the points of most rapid decline of intensity. On general grounds one would expect the depth of the centrum to be considerably less than at the Kulu end of the northern area.

IV.—CAUSE OF THE EARTHQUAKE.

Obscurity of the problem; geological, structural and orogenic features.

In touching on an obscure question of this kind in a publication that is more properly concerned with observed facts, it seems to the writer that all he can do without being too speculative is to show how the whole surroundings of the case, geological, structural and orographical, bear on some standard theory having an *a priori* probability. It will therefore be my endeavour in the following paragraphs to briefly review those surroundings, and attempt to bring out any leading features they may possess, and to show in which way they point. The indications will be seen to be largely circumstantial but at the same time suggestive.

Geology of the area.

The geology of the area was roughly but comprehensively worked out by Mr. Medlicott as long ago as the year 1864.[1] No fresh detailed geological survey of it has since then been made, except in isolated portions near Dehra Dun and further south-east along the foot of the Himalaya; although enough has been done to illustrate the type of geological conditions that prevail along that line of country,[2] whilst a few additional notes collected during my present tour have been incorporated here and there in Part I. From the above we can easily construct a bird's-eye view of the geology

[1] Mem. Geol. Surv. of India, Vol. III.

[2] For summary, see Manual Geol. of India, stratigraphical and structural, 2nd Edition, Chapter XVIII.

sufficient for our purpose, which, as it appears in plan, is represented in the sketch map, fig. 46.

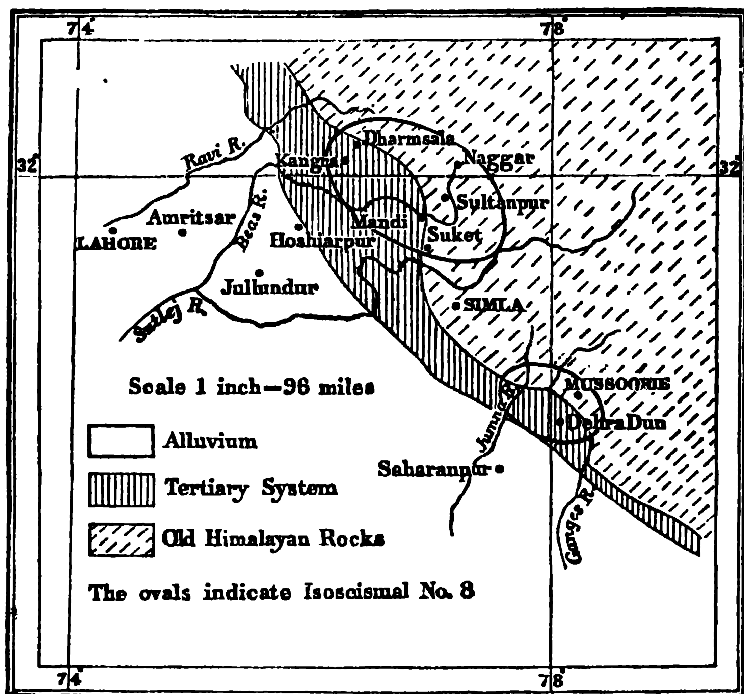


FIG. 46.

That plan shows a striking surface peculiarity at the two points where the epicentres are situated, namely, the great inbaying of the younger Tertiary formation of the Sub-Himalaya towards the higher central regions of the mountains. The line of the "main boundary" fault separating these Tertiaries from the very old Himalayan rocks of that region, may be observed to take a huge sweep inwards and eastwards from the Ravi River to Drang, and then to return almost in a N.—S. sweep by Mandi, Suket and Sabathu, and round the foot of the Simla mountain spurs. The Tertiaries then pursue a normal direction until the Dehra Dun area is reached, when there occurs another but much smaller, inbaying of them towards the central area. Nowhere else

along the Himalayan mountain-foot, as we know it, is there such exceptional irregularity, unevenness one might say, in the disposition of these bordering bands of Tertiary strata.

Coincident with these two inbayings are the two rather similar upland valleys—the Kangra valley and the Dehra Dun—which have come into existence as a joint product of earth movements and rock sculpture.

Structure of the Sub-Himalayan zone.

We may also notice several other striking facts of structure and relief bound up with those just given, facts which although not evident from the sketch map (fig. 46) are well known from other published descriptions and maps. The whole of the Sub-Himalayan Tertiary zone is at a lower general elevation than the older Himalayan tract behind, a feature which obtains throughout the length of the whole range, whilst the valleys also are gentler and the slopes less steep. Furthermore the Sub-Himalayan rocks themselves may be divided up into an older set of harder sandstones which occupy most of the area including the strip of country next the main boundary fault, and a younger set of softer sandstones and shales overlain by thick beds of coarse conglomerate, which only become specially prominent in the flatter parts of the Kangra valley and Dehra Dun. In each case also these younger sets which dip somewhat gently to the north-east under the Kangra valley and Dehra Dun are suddenly reversed on their N.E. edge and separated from the older sandstones by a reversed fault or faults similar in nature to that of the main boundary fault which in turn separates the latter from the older Himalayan series.

Such inversions complicated by fold-faults, which characterise the behaviour of the younger to the older series, have been well studied in the case of the Dehra Dun and the other stretches of country between the Ganges and Sarda river. They were so familiar to the author that there was no difficulty in recognising the similarity on a larger scale that the structure of the Kangra valley bore to them ; and it was soon seen that the position of the actual axial centrum, as derived from the

isoseists, in the case of the Kangra area, was more nearly coincident with that of the reversed fault between the younger Siwalik conglomerate and the older sandstones than with the main-boundary itself. The evidence for the case at Dehra Dun was not, however, sufficiently conclusive, inasmuch as the two boundary faults run very near together at that place.

Himalayan arc.

Another feature of importance is the arc-like curve, convex to the S. W., which the Himalayan range presents to the Gangetic plain. It may undoubtedly be regarded as having gradually resulted from the constant reshaping of that margin by overfolding and faulting. The more marginal the rocks that are involved, the more perfect is the alignment of that curve in all its simplicity: whilst all the areas like the inner side of the Kangra valley and Dehra Dun which are farthest away from that margin are those which show variations from that curve, and must have been places where special local conditions have offered a temporary resistance to the normal onward march of those regular waves of flexure. So long as no exceptional local resistance of this kind interfered, one might be justified in conceiving the regular progression of these folds as happening smoothly and without serious shock, but elsewhere at such centres of complexity we might very well see cause for a struggle of opposing local and general forces which might end in something catastrophic.

These centres of complexity are the places signalised by thick deposits of Upper Siwalik conglomerate. Their presumed deposition from torrential rivers of commensurate magnitude with their similarly situated descendants, the Beas and Ganges of to-day, and the fact of their great thickness and rapid accumulation suggest a disturbing feature of no small magnitude. On the principle of isostasy their continued deposition must have been accompanied by a downward sinking of the Dun areas which would tend to deflect and upset the orderly southerly march of the Himalayan arc folds.

Summarising, we may say that the following features appertaining to the geological, structural and orographic surroundings strike one as

being important from the point of view of the cause of the earthquake:—

(1) The two epicentres lie in the Sub-Himalayan belt, approximately but not exactly along the line of the main boundary fault.

(2) They are located near where that belt widens and shows inbayings towards the older Himalayan mass.

(3) The main epicentre accords with the larger inbaying and the subsidiary epicentre with the smaller.

(4) They are both regions of marked and general change of average level of the country and average steepness of the valleys and ridges.

(5) They are also regions of reversed faulting, where a packing of the strata and an overriding of the younger by the older rock series is specially prominent.

(6) They coincide with parts of those regions where there is irregularity in that packing, and where the regular marginal arc of the mountain, as expressed in the parallel earth folds and faults, is interrupted.

Isostasy.

It is now only necessary to recognise and give full value to the principle of isostasy of the earth's crust, as is clearly demonstrated by all the later work on the fringing ranges of the Himalaya, in order to see the one direction in which all the features enumerated above point. With reference to that principle it must also be remarked that it appears to be not without probability that such an area during the packing process incident on lateral compression of the crust might at certain places temporarily lose its condition of isostasy as regards the subjacent more mobile layers, and become supported (or in part supported) after the manner of an arch, a condition which sooner or later must become unstable and a grand fracture (not a net-work of surface fractures), or even a simple sudden readjustment of strain, take place.

Whilst non-mountainous continental areas of no lateral compression may be supposed to hold together only so long as shrinkage of the

z 2

sub-crustal layers cannot overcome the molecular cohesion of the rock particles, and whilst we may suppose in that case that when failure occurs a large or small area splits up into disjointed masses like an ice-floe in a storm, the case must be otherwise with areas of great orogenic magnitude and relief such as the great mountain ranges of the earth. In these cases lateral compression is the cement which holds the crustal elements together (at the same time that their surface layers are being slowly and continuously sheared and overthrusted) and this is more likely to find relief when isostasy is lost by simple grand fractures at depths proportional to the magnitude of the orogenic features concerned.

What is therefore known as the "tectonic" origin for an earthquake is the one which seems to be favoured by the whole surroundings of the case, and to which the circumstantial evidence enumerated under headings (1) to (6) seem to specially point. Until very good evidence of some other kind can be produced it, therefore, is the theory adopted by the author. It implies that the shock was due to a sudden rupture or release of strain occurring among or below the folded sub-Himalayan formations at two places where the strain was specially great owing to resistances to the well established forward march of the overthrusting foot of the Himalayan range and where packing, with consequent arching, may have brought about a certain loss of isostasy.

Tectonic theory of the earthquake adopted.

V.—EXTRA-INDIAN SEISMOGRAPHIC RECORDS.

The extra-Indian seismographic records of the Kangra earthquake although of great interest to students of seismology, would take us too far afield from what properly belongs to India to describe in detail. Moreover an admirably full account of them has already been prepared by Prof. F. Omori, Sc. D.,[1] with full illustrations of the diagrams.

It is sufficient here to say that the shock affected all long-distance seismographs in the world and that Prof. Omori was enabled to col-

[1] Publications of the Earthquake Investigation Committee in Foreign Languages, Nos. 23 and 24, Tokyo, 1907.

lect either seismographic or magnetographic diagrams from the following places:—Japan, Formosa, India, China, Philippines, Java, Austria-Hungary, Italy, Germany, Sweden, Great Britain, Spain, Mauritius, Cape of Good Hope, Canada, The United States, Mexico, Brazil, New Zealand, and to publish results of seismographic observations from Russia, Samoa, Porto Rico, Hawaii, Syria, Azores and Servia.

The discussion of the mass of detailed figures thereby collected shows it to be a specialist's work in the domain of geophysics, and to be quite independent of the particular point of the earth's surface where the earthquake was sensibly felt. It is a world problem of too general a nature to find a place in these Memoirs.

VI.—THE EARTHQUAKE SOUND.

No sound at all was recorded from the following localities:—

(1) Afghanistan.

(2) Assam.

[*N. B.*—It is not absolutely certain that the shock was even felt by many in Assam. Several records of a shock on the day of the earthquake accompanied by a sound were probably local in origin, or should be considered as aftershocks of the 1897 earthquake. The same remarks probably apply to the sounds reported at Daloo Tea Estate, Cachar, on the evening preceding and half an hour after the shock.]

(3) Baluchistan.

(4) Burma.

(5) Madras.

(6) Nepal.

Of these 6 areas Burma and Madras did not feel the shock, with one doubtful exception in the latter area, and it would be unreasonable to expect the sound to have been heard there. From the other areas only a few records were received, hence the negative evidence in their case is not very strong, especially as regards Nepal and Afghanistan.

In Bengal accounts from 122 places (which include many where the shock was also not felt) record or mention no sound. Of the few places whence a sound is recorded mention may be made of Balasore where it is described as being like "a railway train," Suri (Birbhum

District) where it was like an underground rumbling, and Pusa (Darbhanga District) where it was described as resembling "falling of trees and stones."

In the Central Provinces accounts from 20 places record or mention no sound, whilst only one account from Pendra Road (Bilaspur District) records a rumbling lasting 10 seconds.

In the Bombay Presidency accounts from 23 places (including those from which it was not felt) record no sound, whilst only at Gandevi (Baroda State) was "some little sound" heard.

In Central India and Rajputana at 108 places (including those where no shock was felt) no sound was heard, whilst dull or low-pitched sounds were heard at 28 places. These are variously described as rumbling, thunderings, "like a gun afar off," a railway train, rushing wind; whilst a few are picturesquely defined as "gurr-r-rh, "like a grinding stone," "a thrilling sound," "blow of wind of low degree," or they are mentioned as being "felt."

In Kashmir 45 reports record no sound whilst the rest—8 in number—mention dull rumblings like distant thunder, big guns or heavy carts.

In the United Provinces 256 earthquake forms mention no sound, whilst 77 describe it in the usual way as a sound sufficiently low to be near the limit of audibility, or as "whistling wind through a hollow tube," "rustling like dry leaves," like "echoes of blasting," "moaning" like "top spinning," "rattling as of cannon discharged," "strong bustling" and so on. Some of these peculiar descriptions probably depend rather on the writers' unfamiliarity with the English language than on a really correct diagnosis.

In the Panjab and North-West Frontier Province 290 accounts mention no sound, whilst 85 record deep sounds as varied as those before described, and including near the epicentral tract "roarings," "booming noises," "hammerings," "roarings and gurglings." A few descriptions are very cryptic, *e.g.*, "sound like clouds", "calm storm," ' rackety windy sort of noise," "growling," like "shau-shau," "dog's tail on the ground," etc.

A large number of accounts make no reference as to whether the sound was heard before, during or after the shock. Of the remainder the larger part record the sound as beginning or occurring just before or a few seconds before the main shock; a fair number record it as occurring during the shock, and a very few as subsequent to the shock. From this evidence it is clear that the shock was in a great number of cases heard some little time (measurable in seconds) before the shock (or the main shock) was sensibly felt. It is also clear that it continued during the shock; whilst the evidence that the sound was sometimes not heard until after the shock may be variously interpreted, but most naturally on the assumption that it was simply not noticed till afterwards. The human ear being unable to record very low-pitched sounds, it is more probable that the varying evidence is due to the imperfect receiver than that there was any real difference at different localities in the order of the phenomena. My own personal experience of the sounds accompanying such of the aftershocks as were observed by me is entirely in favour of this conclusion: the sound was never heard after the felt shock, but generally sufficiently before it to arouse expectation for the latter.

Relation of the sound to the shock.

In consideration of the low rate of transmission of sound waves in air, about ⅕ mile per second, and in consideration also of the only moderate intensity of the sound even in the epicentral regions (insufficient to break glass windows, as we have seen), there is no other possible conclusion than that the more rapid vibrations capable of creating a sound were transmitted to the air from the ground in the immediate neighbourhood of the observer. Assuming then that there is sufficient testimony in support of the sound having begun to be heard slightly before the appearance of the felt shock, we must conclude that these more rapid audible vibrations were communicated to the air from the surrounding ground, being borne as subordinate partial vibrations superposed on the not yet felt preliminary tremors of the direct shock. Wherever the sound was not noticed until during the main shock we must suppose that they were not of sufficient intensity, or of sufficiently

high pitch to affect the observer's particular tympanum until the direct condensational wave that carried them along had itself developed its full swing.

Although the large number of records rendered available by means of the earthquake forms have, as we have seen, given many discordant results concerning the nature of the sound and its relation to the shock, one valuable and certain conclusion seems to have been established which could not have been obtained in any other way than by such diverse written testimony. We may in fact be quite certain from the *general coalescence* of the time of sound and felt shock that the two came together transmitted through the same medium. The sound as heard in any given locality could not have been an intense sound emanating from certain definite lines or points on the earth's surface, at a distance from the observer and transmitted through the air, and consequently weakened and dissipated by distance. Otherwise these sounds would have followed the shock at ever-varying periods after it, rolling in like distant thunder does many seconds after a flash of lightning. The evidence unmistakeably points to the fact that the aerial vibrations that have their immediate effects on the auditory nerves are purely locally derived from the ground beneath each observer. This fact, coupled with the known varying and defective impressions due to the limited registering powers of the individual ear, render the great variety in the precise time, nature, and progress of the described sound perfectly natural and understandable.

VII.—MISCELLANEOUS PHENOMENA OF THE EARTHQUAKE.

Effects on Canals, Rivers and Streams.

Bari Doab Canal.

In the Bari Doab Canal between Bhimpur (10 miles south of Pathankot in the Gurdaspur District) and Sathiali (10 miles south of Gurdaspur) Mr. F. E. Kanthack, Executive Engineer, 1st Division, Bari Doab Canal, from personal inspec-

tion and enquiry found that the water rose to a height of as much as 6 feet at various places within a distance of 30 miles (see map, pl. 29). He felt the shock in the Bhimpur bungalow, which rocked so much that he could hardly make his way to the opposite end of it, where his wife and child were sleeping, although no damage was done to the bungalow. "Immediately after the earthquake," he writes, "my attention was called to a loud noise coming from the main line of the Bari Doab Canal which, at the point of observation, runs in a 40 feet cutting about 20 yds. from the bungalow. I found the canal which was here 150 feet wide, in violent agitation and swamping ground 6 feet above the usual water level." He also found the points of greatest intensity to be those where the canal ran N.N.E.—S.S.W., and the water, according to a reliable witness, first went over the bank to the E.S.E. and afterwards to the opposite bank, reaching a slightly lower level there. On the other hand the Kasur Upper Branch, which takes off at Tibri (near Gurdaspur) and which runs in a direction N.W.—S.E. had no movement of water observed at all. In another case at Sathiali two branches take off at right angles to one another in the directions N. by W. and W. by S., and here the height to which the water rose was 5 feet in each case. Mr. Kanthack concludes from these observations that the tilting of the ground which produced the rise must have had a direction about E.S.E.—W.N.W. He notes it as peculiar that from the head of the canal at Madhopur down to mile 12, at Bhimpur, although the canal runs generally N.—S., the water only rose 1 ft. or less on the east bank. The velocity, however, in this upper part is much greater and may account for this.

Lower Chenab Canal.

At Khanki in the Gujranwala District (see p. 201) the water has been described as rising in the river and in many of the canal branches to a height of 0·20 to 0·10 [? feet].

Other canals, etc.

Mr. R. R. Simpson (p. 116) has referred to the breaking of the Bhimgoda "bund" near Hardwar on the Ganges. He has also described (p. 124) the case of the Solani aqueduct on the Ganges Canal. At Raya, Amritsar district (see p. 192), water from the canal spread over the canal bank. At Dadupur on the

west Jumna Canal, the canal water waved and small boats were thrown out by the serious beat of the first shock (see p. 196). At Dhanaura Karnal District in the W. Jhelum Canal (see p. 208) the water waved about 3 feet higher on left bank than the original surface.

Dehra Dun streams.

Lieut.-Colonel S. Burrard, Superintendent, Trigonometrical Survey, made some enquiries regarding the effect of the earthquake on the water supply drawn from certain streams, in the Dehra Dun. Mr. P. Denehy, Assistant Engineer, Irrigation Branch, Dun Canals Division, in reply said that he only knew of two authentic cases where the volume had been increased, namely, the Tons-Nalota and Rispana torrents. These streams were completely closed, and all their water was being taken into the canals on the 3rd April (the day before the earthquake). On the morning of the 4th immediately after the earthquake, the gauge of the Bijapur canal which was taking in the Tons-Nalota waters, went up from 2·0 feet to 2·5 feet, which is equivalent to an increase of discharge of 12 cubic feet per second. The gauge of the Rajpur canal, which was taking in the whole of the Rispana water, went up from 0·40 feet to 0·70 feet which is equivalent to an increase of discharge of 12 feet per second.

The above was immediately after the earthquake. But at the time of writing (1st June 1905) two months after the shock the increase in the case of the two canals above normal for that time of the year was 17 cubic feet in the Bijapur canal and 4 cubic feet in the Rajpur. It should be noted, however, that all the streams in the Dun had been running very high during the year on account of the abnormally heavy winter rains, and Mr. Denehy felt it impossible to say how much, if any, of this should be attributed to the earthquake.

Kumaun Division streams.

The following note by Forest Ranger, M. S. Rawat, in the *Indian Forester* for September 1905, referring to the Kumaun Division, is of interest in this connection :—"At Chaunsila, 12 miles from Naini Tal, the general scarcity of the stream water sets in yearly, and by May not a drop is to be found for 2 miles in each direction. But from the date of the earthquake a large amount of water has been flowing throughout the whole of the dry

season. Owing to the same cause the volume of water in the three streams : Deigaon Sot (Dechauri Range), Tilaur Sot and Nehal N. (Fatehpur Range) has been increased by about three times."

Ganges, Jhelum and Indus.

The Postmaster at Srinagar (Garhwal) (see p. 186) reported the Ganges "stopped during the earthquake." At Srinagar, Kashmir, Mr. B. Thornhill, Chief Engineer, Kashmir Railway Survey, noticed a wave or swirl of water coming down the river from his house-boat (see p. 191). At Kalabagh the waters of the Indus were "disturbed and ran up the banks."

Kapti and Ami rivers.

At Gorakpur on the Kapti river a tidal wave was observed and it left its marks on the river banks. Also at the Ami river the water in bridge-foundation wells was much agitated, spilling the water over the tops.

Among all these effects on canals and large rivers, the first at Bhimpur on the Bari Doab stands out as the most significant, as should be the case considering its proximity to the epicentre and to the point where thick alluvium, capable of generating long undulose movements, first makes its appearance.

Effects on Springs.

In the descriptive part of this memoir a number of instances of the effects of the earthquake on springs have been adduced. Among them may be mentioned those of Jawalamukhi (p. 10), Manikarn (p. 63) and Manali (p. 76). It is not easy to draw any hard-and-fast line between springs and torrential streams, as regards the effects of the quake upon them, inasmuch as the former supply the latter, but it is natural that anything that tends to open up, seal, or alter the flow of underground percolation will also have a very similar effect on the streams which are fed by such springs. Generally, as would be expected, the effect is to open up by shaking, with the result that there is a greater supply for the time being.

Mackinnon's Brewery, Mussoorie.

The springs at Mackinnon's brewery, Mussoorie, increased their discharge by from 20 to 30 per cent., a result accurately determined by Mr. P. W. Mackinnon. After 20th May the increase showed a gradual falling off until the end of June when the streams resumed their normal flow.

Variation of levels between Saharanpur, Dehra Dun and Mussoorie.

The following details, kindly furnished me by Lieutenant-Colonel S. Burrard, seem to show that Dehra Dun and the Siwalik range to the south have been elevated relatively to Saharanpur and Mussoorie since the earthquake. The amounts of the elevation being so slight (only a matter of a few inches) in such a long and steep course, the statements are given with all reserve.

The facts are that in 1862 the line between Sahranpur and Mussoorie was first levelled. This was repeated in 1904 (the year before the earthquake) so far as the portion between Dehra Dun and Mussoorie is concerned. Again in 1905 after the earthquake the latter portion was again levelled with the object of seeing if any change could be detected, and a diminution of about 4 inches was found in the difference of height between the two places with proportionate diminutions at points on the way. These last two experiments were carried out in May of their years, but the results were ambiguous inasmuch as they might be interpreted as either a rise of Dehra or a sinking of Mussoorie. To settle this point, and also to verify the whole thing sanction was obtained, and the whole line relevelled from Saharanpur, to Mussoorie in the cold weather of 1906-07. The results corroborated the 1905 levellings and established the fact that it was Dehra Dun and the Siwaliks which had risen and not Mussoorie which had sunk. As it must have taken place between May 1904 and May 1905 it is conjectured that it happened during the earthquake.

It may be mentioned that the greatest care was taken in levelling over such a long and mountainous tract, the reliability of the staves and the comparison of them with a standard steel unit kept at Dehra Dun being duly attended to It is also necessary to emphasise the

fact that in the last levelling along the whole line the results agree so closely over much of it.

The following is the tabular statement of these measurements and a section is shown at pl. 27:—

Table showing the results of levelling between Saharanpur, Dehra Dun and Mussoorie.

Names of points.	Heights determined in 1862.	Heights determined in 1906-07.	Difference.	REMARKS.
G. T. S. Embedded B. M. at Saharanpur.	907·25	907·25*	..	* Accepted as origin.
Standard B. M. at Saharanpur	..	902·728	..	..
G. T. S. Embedded B. M. at Mohan	1,489 40	1,489·730	+ 0·330	..
G. T. S. Embedded B. M. at Mohabawala.	2,096·56	2,096·925	+ 0·365	..
E. End of Dehra Dun-Base Line	1,959 07	1,959·464	+ 0·394	...
Iron Plug at Trigl. Branch Survey Office at Dehra Dun.	2,229 132	2,229·576	+ 0·444	...

Height of Bench Mark at Vincent's Hill, Mussoorie, determined in May 1904, accepting Dehra as correct	7,129·315
Height of Bench Mark at Vincent's Hill, Mussoorie, determined after the earthquake in May and October 1905, accepting Dehra as correct	7,128·897
Height of Bench Mark at Vincent's Hill, Mussoorie, taking the new value of Dehra determined in 1906-07, accepting Saharanpur as correct	7,129·341

Earth Fissures.

It has already been insisted on that not one, or scarcely one of the earth fissures, whether occurring in rock, soil-cap or alluvium, have originated from anything except the severe shaking to which, as the result of the earthquake, the slopes and alluvial flats near free edges have been subjected. Great numbers of these have been described and referred to in my description of the more precipitous part of the Dhauladhar and the higher ranges of Kulu. Others in alluvium have also been mentioned by myself and my colleagues in the neighbourhood of Kangra, Dharmsala, Mussoorie and Rurki.

Several other cases have also been recorded in the earthquake forms, such as those at Amballa (see p. 194) and Dhanaura (see p. 208). A rather more interesting case than usual is described from Khanki in the Gujranwala District (see p. 205). There earth fissures in all directions are found in the soft ground 2 miles long on the right bank of the Chenab. There were also 2 holes (craterlets) 30 feet in diameter and 4 feet deep from which fissures radiated, the largest being 2 feet wide. Water in great volumes is said to have issued from these fissures.

The only case of a true rock fissure that seemed to penetrate into the rock and to be connected with and a part of the rock folding of the region was one which I saw at Barwar lake near Larji. It is among folded limestones and strikes N.W.—S.E. It lay along a line of faulting and had perfectly fresh surfaces. Inasmuch as it dipped or haded into the hillside and not down the slope it was not (directly at least) connected with any downward sliding with gravity. On the whole it suggested fresh movement along an old fault.

The shock at Cochin.

The following account from the *Pioneer* of 14th April 1905 at first sight would seem to show that the earthquake of the 4th was really felt in the Madras Presidency, and at a considerable distance away from what has been marked as the outermost limits of the felt shock :—

Earthquake shock at Cochin.—A Cochin correspondent writes under date the 6th instant:—A distinct shock of earthquake was felt here on the morning of Tuesday last, 4th April, at 6-30, the occurrence being of a very extraordinary nature. While the Bishop's Secretary was preparing for his morning service in the Cathedral, he felt a tremor in his room in the Bishop's residence. While going into the Chapel he saw the lamp that was burning there, suspended from the ceiling, moving to and fro. All the inmates of the Bishop's house felt the shock. It lasted for a few seconds, the wave travelling from east to west. What was most extraordinary in this connection was that the shock was felt in that building only, and nowhere else in Cochin, as I learnt from enquiries. The Bishop's residence is situated on an eminence which was once the part of a Portuguese rampart and it is unaccountable how that building alone experienced the shock.

On the other hand it should be remembered that on the 2nd April there was a very smart shock of earthquake at Ongole and other places in the Madras Presidency which also was followed by aftershocks. It is therefore quite possible that the time of the Cochin shock, so near the right time for the Kangra earthquake, is only a coincidence. The following are cuttings from the *Englishman* of 7th and 10th April referring to this earthquake :—

Ongole, April 2nd.—A severe shock of earthquake was felt at Ongole at 8·48 A.M., lasting ten seconds. Buildings and men were rudely shaken. The walls have cracked and tiles were swept off. The hospital buildings have been damaged and the people are panic-stricken. Though earthquakes are frequent here, none has ever been so severe. There were no accidents and no loss of life. There were slight repetitions at intervals and the school-children were terror-stricken.

Another correspondent telegraphs:—A serious shock of earthquake was felt here this morning a little before 9 o'clock. The college boys and orphan children were gathered in the College Hall upstairs in the American Baptist Mission, and the Rev. J. David was just about to end his sermon when the building began to shake terribly and the plaster from the roof dropped on the people. A panic almost ensued as the children ran pell-mell down the narrow stairway. One little girl got hurt and bruised, but not seriously. The college buildings as well as the Principal's bungalow are considerably damaged. The walls are badly cracked and the tiles have slipped off from parts of the roof. The shock was felt all over the town and several small houses were damaged.

A slight shock was felt about 8·4 A.M. on the 2nd instant, in Madras, the direction being from east to west and the duration about 15 seconds. The Observatory, having no seismograph, is unable to give further particulars as to the intensity of the shock.

A Markapur (Kurnool) correspondent writes:—Yesterday (2nd April), a little before 9 A.M., there was a shock of earthquake here which lasted for several seconds and was severe enough to cause the dishes on the sideboard and dinner wagon to rattle quite loudly. The bungalow trembled and groaned while it lasted, but there was no damage done. The sound accompanying the shock resembled the rumbling of distant thunder or the sound caused by a train passing over a large iron or steel bridge.

Ongole.—An Indian correspondent wires on the 6th: Since Sunday there have been several earthquake shocks daily. Parents are alarmed for their children's safety. Yesterday the Mission College students and teachers refused entering the college. The Missionary Professors expect averting the danger through prayers immediately. At 11 A.M., severe shock, the boys jumped out of the windows, strength 350. Fifty attended in the afternoon. Again a shock at 7-37 P.M. shook the building. On Sunday a memorable shock shook the college building up and

down. Fearing volcanic eruption. Ongole notorious, three shocks annually Oldest men never experienced so many so severe. In the morning at 3-50 A.M., another shock, total 15 till now. Town abandonment absolutely necessary, must remove offices, Sub-Collector inspected the buildings which were condemned. The people panic-stricken, not sleeping.

Damage to the Telegraph.

Of damage to the telegraph in Kangra and Kulu, 190 miles of line, 239 poles, including a few terminals, were either broken, knocked down or tilted over. 13½ miles of wire in the aggregate were lying on the ground broken in several places. Telegraph buildings and instruments shared in the general destruction, but fortunately only one postmaster in charge of a combined office was killed.

Effects on Animals.

Scattered about in the pages of the descriptive part will be found numerous allusions to the way animals comported themselves during the earthquake. It seems in many cases to have made horses restive On birds it had a very immediate effect in consequence of the shaking of the trees. Dogs and cats were also affected (p. 45). The animals in the Lahore Zoo were highly alarmed and "created a great uproar, the piercing shrieks of peafowl being predominant."—(*Englishman*, 6th April).

The Kashmir Seismograph Trace.

Although I have been unable to reproduce and discuss the long-distance seismograph records of this earthquake from other parts of India and in other lands (work which has, however, been done far better than I could hope to do by Prof. Omori) there is one seismogram which is of interest because it was traced within the seismic area at Srinagar in Kashmir, and has not been mentioned by Prof. Omori. I have received through Dr. Walker, Meteorological Reporter to the Government of India, copies of this seismograph trace, and I have also had some correspondence with Dr. A. Mitra, Meteorological Reporter to the Kashmir State, with reference to the same.

The instrument there installed is of the pattern known as the Milne-Casella. It is not intended for long-distance quakes but for those of ordinary intensity in the neighbourhood of the station. The recording part of the instrument does not travel constantly but is automatically started by the shock. It gives a large open trace on smoked paper.

Unfortunately the trace has overlapped itself 3 times, and in the photographic reproduction kindly sent me by Dr. Mitra, it is impossible or very difficult to sort the 3 traces. A few results seem clear.

(1) The time of commencement by the stoppage of the clock in connection with the instrument is given as 6H. 10M.

(2) The time taken for the whole traces was 3 minutes 50 seconds.

(3) The vertical component of the shock was extremely slight, showing only about $\frac{1}{8}$th to $\frac{1}{10}$th inch movement.

(4) The N.—S. and E.—W. traces are about equal in amplitude, the greatest sweep being over 4 inches range. The natural magnification appears to have been about twice, but the position of the instrument on a table in a closed verandah is not good.

(5) Other points are not certain, but if one reading of the trace is taken as correct, there appear to have been two phases of large amplitude waves, the second being of longer duration, more rapid and greater amplitude. If this is so, it would confirm the frequently repeated statements that the second shock was the more intense and long continued.

In addition to the above details from the seismogram, the following notes by Dr. Mitra may be added :—

(1) Almost all pendulum clocks were stopped. In one the fine spring of the pendulum broke and it dropped down.

(2) Some bottles in the chemical laboratory were overturned, chiefly those made of thin Bohemian glass. A flask which was boiling over a spirit lamp fell towards west and was smashed completely, similarly also a wash bottle. No bottle in the dispensary room of the State Hospital was overturned.

(3) Hanging lamps were found swaying vigorously from S.E. to N.W.

(4) Trees, both large and small, were swaying in the same direction.

(5) No sound was heard. In 1885, booming sound as of a distant thunder or gun was heard.

(6) There was a swell on the river Jhelum, the direction was from E. to W.

(7) In Hazaribag there is a circular masonry tank with a fountain in its centre. It was full of water. After the earthquake it was found 6 inches empty, the water being splashed all round but not more in any particular direction than others.

(8) In the main water-supply 12-inch pipes from Nishatbag to Rainawari there were 25 leakages caused by disjointing.

The following is the list of houses which partially suffered :—

Cracks in chimneys in houses occupied by Mrs. Losack, Mr. Talbot, Rai Bhawni Dass and 2 houses in the city. Crack in walls of new Memorial Ward State Hospital, and a few other houses. Nine houses in the city suffered more or less, but in none anything serious happened.

(9) From the examination of the Barograph, no definite pressure variation was observed except a slight depression commencing at 3 A.M. lasting till 8 A.M., but that is a part of the usual diurnal variation. The records being as follow :—

3 A. M.	24·917
4 „	24·910
5 „	24·912
6 „	24·920
7 „	24·940

(10) Half-an-hour after the earthquake another very mild tremor was felt, moving the needle ·5 cm.

CHAPTER VI.

FORESHOCKS AND AFTERSHOCKS.

1.—Foreshocks.

When writing my preliminary report of this earthquake I had no evidence at my disposal in favour of any foreshocks having been felt in the disturbed area. Since then, the detailed sifting of the earthquake forms has revealed distinct evidences for a few premonitory shocks that may be considered to be of the nature of foreshocks or warnings of the big event. It is according to common knowledge that many destructive earthquakes are preceded by a few such premonitory shocks. Mr. Davidson writes: [1] "For a few hours or days beforehand weak shocks and tremors are felt or a rumbling is heard within the future meizoseismal area. In the 1891 earthquake in Japan the previous two years was characterised by a greater frequency of earthquakes in this area. Even the future fault-scarp was mapped out by them."

So far as is at present known, there is no means of distinguishing such foreshocks from ordinary small shocks which may visit an area without being succeeded by a great shock. Consequently their value as actual warnings of a coming catastrophe is at present nil. This may, however, be merely owing to our imperfect analysis of such shocks. With a more perfect system of registration it may be that in the future it will be possible to distinguish these warning tremors from mere small local disturbances. This would be the more likely to come about when seismographs are more plentifully distributed than they are at present over known earthquake regions.

In the brief list which follows it will be seen that the foreshocks recorded (probably only a fraction of those which actually occurred)

[1] Recent earthquakes by C. Davidson.

are limited to the day before, and the early morning of the actual day of the earthquake. The evidence for one about 2 A.M. on the latter date is the most substantiated. The list is arranged chronologically.

Date and time.	Place and authority.	Remarks.
3rd April 1905 between 8 and 12 noon.	Amritsar, Lieutenant J. G. Skene, 5th Gurkha Rifles.	He thought he felt a shock.
3rd April, 11 P.M. .	Nagina, U. P., Meteorological Signaller.	Two seconds' duration.
4th „ 1-30 A.M. .	Simla, M. S. D'Cruz . .	Very slight shock felt on 3rd floor.
„ „ 2 A.M. .	Nagina, U. P., Meteorological Signaller.	Two seconds' duration.
„ „ „ .	Meerut, U. P., R. Bruce Spilsbury, Assistant Engineer, P. W. D.	One and-a-half minutes' duration, slight, rattled crockery and woke him up.
„ „ .	Simla, *Statesman* of 9th April .	Awoke many people.
4th April between 3 and 4 A.M.	Mussoorie, Miss Hope of "Clairville."	She heard creaks and dogs barked.
4th April, 4 A.M. .	Amritsar, F. W. Schonemann, Executive Engineer, Bari Doab Canal.	His wife heard a door rattle, and Mr. Roberts in the same house thought it was thieves.
„ „ „ .	Kandi Travellers' Bungalow, Kulu, Rev. J. Tunbridge, C. M. S.	Heard boards rattling which his wife declared to be an earthquake.
„ „ about 5-30 A.M.	Sardhana, Meerut District, Hira Lal, Sub-Postmaster.	

In addition to the above Mr. R. L. Bonnaud, Panjab Educational Department (retired), in his earthquake form mentions that subterranean sounds of the nature of Barisal Guns (see p. 177) which have been common in Ludhiana for long ages, were heard with peculiar loudness a few days before the earthquake, whilst since the shock there has been a lull.

2.—Aftershocks.

General remarks.

In contradistinction to foreshocks, the occurrence of aftershocks succeeding any big earthquake is a matter of universal experience. Immediately after the big shock

they are numerous and of an order that would entitle many of them by themselves to be ranked as violent earthquakes. They may continue for days, weeks and months after the parent shock; whilst, in the case of earthquakes of the magnitude of the Kangra earthquake, they persist for years—often with recurring periods of maxima and minima. Very frequently they affect various parts of the epicentral area at different times, as if one portion after another of the originally disturbed crust felt the need of further relief. Frequently also a more than usually violent aftershock, originating at one locus of the first-affected area, is succeeded by a set of aftershocks that are evidently secondary in origin, and belong more properly to that aftershock than to the first grand seismic disturbance.

List of aftershocks: imperfections of.

Most of the above points are clearly illustrated in the list of aftershocks that followed the earthquake of 4th April 1905. In that list, in spite of its size, the prevailing character is its imperfections. It is imperfect for many obvious reasons and along many lines, but principally for the reason that, with the exception of the larger aftershocks that were noticed in the newspapers, no record was commonly kept or submitted by observers when once the earthquake-forms had been filled in and finally despatched to the Geological Survey Office. The dates when this was done varied considerably according to circumstances, and as a consequence the records break off suddenly and irregularly here and there over the enormous area reported on, without there having been any corresponding real cessation of the shocks.

Other sources from which the list has been compiled.

There were, however, a few other sources from which the list was compiled. Such were the seismoscopes and seismographs in ordinary use in the meteorological observatories,[1] the newspapers, and letters from many private persons who interested themselves in the matter. A large number of aftershocks were also collected by Lady Holland at "Kenil-

[1] Early manuscript copies of the monthly list of earthquake shocks at Simla were supplied me by the courtesy of Dr. Gilbert T. Walker, M.A., F.R.S., Meteorological Reporter to Government of India and Director-General of Indian Observatories.

worth," Simla, with the assistance of an Agamennone instrument, which observations were continued later with the same instrument by Mrs. W. Henry at "Kelvin Grove." A few aftershocks were collected by myself during my tour in the epicentral tracts.

A systematic registration of aftershocks undertaken by a band of amateur observers.

But, besides the immediate successors of the great shock it became desirable to institute a regular system of recording the fainter, as well as the more violent, aftershocks; so long as they continued to be felt at all in the regions surrounding the main seismic centre. For that purpose a number of gentlemen and ladies very kindly undertook the task of noting such on specially prepared forms, giving such details as to time, date and approximate intensity as could be furnished without specially installed apparatus. Among these may be mentioned :—

Alston, Lieutenant R. C. W., Chakrata.
Anderson, Captain A., District Engineer, Dehra Dun.
Ballard, Mr. W., Holta Tea Estate, Palampur.
Burrard, Lieutenant-Colonel S., F.R.S., Superintendent, Trigonometrical Survey of India, Dehra Dun.
Hatch, Major A. V., 2nd Battalion, 1st Gurkha Rifles, Dharmsala.
Holland, Lady, "Kenilworth," Simla.
Henry, Mrs. W., "Kelvin Grove," Simla.
Keatinge, Mr. J. A., Municipal Office, Mussoorie.
Kiugh, Rev. L., Chaplain, Mussoorie.
Mackinnon, Mr. P., "Lyndale," Mussoorie.
Osborn, General W., Naggar, Kulu.
Playne, Miss A. E., B.A., Caineville School, Mussoorie.
Pope, Miss M. E., S. P. G. Mission, Rurki.
Rennick, Colonel R. F. H., Bajaura, Kulu.

No aftershocks recorded so far away as Calcutta.

It does not appear that any of the aftershocks, with the exception of one, were recorded so far away as at Calcutta by the Milne seismograph of the Alipore Observatory. Out of a list of 38 earthquakes appearing in the record of that instrument from 4th April to 8th November, and kindly

furnished by Mr. J. A. Cunningham, Acting Meteorological Reporter to the Government of India, it is not possible to correlate any one with those recorded from Upper India. The big shock itself was, of course, registered, but it was apparently not followed by any others capable of influencing the far distant instrument at Calcutta until the 28th February 1906. The register of the big shock stood absolutely alone even on the day of the shock itself when severe and numerous aftershocks shook the meizoseismal area.

Doubtful aftershocks from neighbouring regions.

A few shocks from neighbouring regions such as the Murree Hills, Rajputana, and even Baluchistan will be found included in the list of aftershocks, not in the belief that they are simple aftershocks proceeding from the main centrum or from subsidiary more superficial local centra connected with the main centrum, but because it may be convenient to have these outside local shocks handy for comparison, in case it may be shown that the responsivity of outside unstable regions is in any way sympathetically aroused by the near presence of an area where aftershocks are in the chronic stage—a supposition that might well be maintained. Some notable foreign shocks are added.

To be ideally complete, an account of the aftershocks should not only supply us with the exact time, but should also tell us something about the areas over which each was felt, and more particularly the place of the epicentrum—as to whether it showed any tendency to wander to more outlying portions of meizoseismal area. It should also give us certain measures of intensity just as in the case of the parent shock. In what follows it will be seen that we are very far from being able to compile such an ideally complete account.

Brief analysis of the list of Aftershocks.

Great frequency of the early aftershocks more apparent than real.

During the day of the earthquake and the next few succeeding days the evidence points clearly to a very large number of shocks, but it should not be forgotten that many recorded as separated in time by only a short interval were probably synchronous, depend-

ing for their apparent separation merely on defective time observation. The truth of this will be apparent if we for a moment consider the big shock of the 4th itself. We know that this was a single phenomenon whose time of occurrence could not have varied more than about 7 minutes at most. But, if this shock had not been recognisable by its predominating features, and we had merely regarded the successive times at which any shocks have been recorded in the lists, this one shock would have the appearance of being a series extending from long before 6 A.M. to long after 6-30. It follows from this that the extremely large assemblage of aftershocks, which in the list appear to follow the big shock, are not really so many actually distinct shocks. On the contrary they must represent a much smaller number of actual occurrences that have become, so to speak, spread out by accidental misrepresentation of the noted times.

A check on the above misconception.

We fortunately possess a means of checking any gross form of mistake due to this unnatural fullness of the list, inasmuch as some of the first statements in that list are of a general kind—so many aftershocks being recorded as having occurred within so many hours after the main shock. And it is very noticeable that these individual statements from typical localities regarding the frequency of the aftershocks during the first day fall far below what would be surmised from a glance at the list. For instance we have :—

Hoshiarpur . . .	1 aftershock	every	1	hour.
Naggar . . .	2 aftershocks	,,	1	,,
Simla . . .	1 aftershock	,,	1	,,
Sialkot . . .	7 aftershocks	,,	4	hours.
Ludhiana . . .	9 ,,	,,	4	,,
Ferozepore . . .	7 ,,	,,	4	,,
Mussoorie . . .	3 ,,	,,	1	hour.
Average . . .	30 ,,	,,	16	hours.

or an average of 1 every 30 minutes instead of 1 every 2 or 3 minutes as shown in the chronological list. Let us, however, but assume that the actual sensible aftershocks did really occur not more frequently than

1 every half-hour, and it is clear that records for one every 2 or 3 minutes would certainly appear in the earthquake forms if we allow that the average clock was not accurate to within half-an-hour (a perfectly reasonable supposition in outlying stations in India).

Frequency of aftershocks as shown by the magnetographs at Dehra Dun.

In support of the above assumption may be mentioned here the records of the H. F. magnetograph at Dehra Dun. That instrument recorded 15 aftershocks between 6-21 A.M. and midnight, the several times being:—6-21, 6-29, 6-31, 6-46, 7-39, 7-51, 8-56, 9-4, 13-41, 13-59, 15-50, 17-55, 18-30, 21-59, 23-59. The average here exhibited is about 1 every hour, although 4 are recorded in the first hour, and there are some notable gaps, as between 9-4 and 13-41. Dehra Dun is, however, rather far away from the larger centre, although on the other hand the magnetograph probably recorded shocks that were not sensible to men.

Having then just cause to believe that the severally recorded shocks in that crowded early part of the list are by reason of imperfect timing inextricably mixed up with one another, it becomes manifestly impossible to do anything more with the data than to conclude that over such and such a general area including such and such big towns, aftershocks occurred about 1 every 30 minutes during the day of the big event.

With the date April 11th the list begins to thin so considerably, as regards frequency, that aftershocks in widely separated localities can now be reasonably correlated. For instance the shocks reported at Gurdaspur, Simla, Mussoorie and Landour, Dehra Dun, Manglaur and Mandi between the reported times 10-30 A.M. and 12 midday are probably one and the same shock. We may therefore conclude that it was felt over the area including those places, but negative evidence that it was not felt elsewhere has not much value.

On April 15th again, there is the same sort of evidence for a shock about 6 A.M. felt at Mussoorie and Landour, Rurki, Kulu and Muzaffarnagar. At Rurki it was distinctly felt and doors rattled, whilst in Kulu it is reported as the worst since the shock of the 4th.

From the 15th to the 23rd it would seem that the aftershock area shifted towards the east and south-east into Kulu and the Mussoorie region. A few shocks noted from Baluchistan and Chitral about the same time being obviously not directly related phenomena.

On May 3rd prominent aftershocks were first noticed by the author in the epicentral area near Palampur (I had been on the ground since 12th April) accompanied by landslides in the Neogal gorge, but none of these coincided with shocks reported elsewhere except at Dharmsala.

For the latter part of May up to the 28th the records available are principally from Kulu, after which an Agamennone seismoscope set up in Simla by the Director of the Geological Survey begins to record, sometimes coinciding with the Kulu records, but very frequently only marking local aftershocks in the Simla area. Thus we may perhaps correlate the shock on May 30th at 2 A.M. in Kulu with that on the same day at Simla at 2-18. Also the one on June 10th at 1-20 A.M. at Simla and 2 A.M. at Naggar (Kulu) said at the latter place to have been very severe. Also the one on June 14th, about 3 A.M. at Mussoorie and Naggar.

On June 27th, we may correlate the 6-15 P.M. smart shock at Mussoorie with the 6-17 P.M. one at Simla, felt generally and by the author in the Town Hall which rocked endwise with a slow motion, and possibly with the 6-28 P.M. one at Dehra Dun.

From then on to July 26th there is not much to note in the list beyond records from Dras and Skardu (probably local shocks) and the general agreement of the Agamennone seismoscope and the Omori seismograph (from that time also installed at Simla by the Meteorological Department).

The shock of July 26th was felt at Dehra Dun, Mussoorie, Simla, Dharmsala and Ferozepore. At the first place it is described as the severest since the big shock, at Mussoorie it roused the station, at Simla many people rushed out of their houses, at Dharmsala it was smart, whilst at Ferozepore there was a rumbling noise from the north-east, many people were disturbed and walls and roofs, etc., shook. From the absence of any reference from Kulu it would seem that the shock

was not felt, or not severely felt there, whilst the account from Ferozepore helps to suggest a more southerly locus for this aftershock.

During the rest of July and early August a number of small aftershocks are recorded, but on August 12th there was a severe shock recorded from several places in the Murree Hills. As this is only nearly coincident with one recorded in Kulu it seems probable that it had a local origin and was perhaps quite independent of the centrum of the big earthquake of April 4th.

On August 25th the two severe shocks reported from Deesa (North Gujrat) stand alone and were probably also of local origin.

During this month, as also in previous ones since seismographs were set up in Simla, there are some noticeable agreements between the shocks reported from Naggar or Bajaura in Kulu and those recorded by the seismographs, as also between other points in the great earthquake area. In the case of the former the agreement most likely indicates a single deep origin. But besides these there undoubtedly have been recorded from Kulu a large number of shocks which gave no trace in the Omori seismograph and did not affect the Agamennone seismoscope. These must, therefore, have proceeded from origins less deep, and have had only a local effect round about Kulu. There is no reason, however, to doubt that they were somehow and distantly connected with the original centrum possibly by means of lines of fracture which are unknown to us.

In many cases, as the records show, shocks in the Kulu area have been followed or preceded by shocks in the Dharmsala or Simla areas—the records are sandwiched in fact—a state of things which seems to indicate that a superficial (or near the surface) readjustment in the one place called for an early re-adjustment in the others, so as to balance results on each side of the deep main centrum.

Nevertheless, taken as a whole, the Kulu valley seems to have been richer in aftershocks than any other part of the meizoseismal area. This cannot altogether be apparent only and due to the more conscientious recording done by our fellow worker, Colonel Rennick (admirable as that was). It must have been in large measure real, and a probable

explanation may lurk in the larger scale on which the mountain and valley features are represented in Kulu. The steeper and longer slopes, the more profound gorges and precipitous crags, as has already been shown in the narrative part of this book, were much riven by surface slips during and for long after the earthquake. Now, although it is not to be supposed that a rock slide, even on a grand scale, would cause a tremor that could be felt even a few miles away—it being far too superficial for that—it is quite likely that the ragged surface of Kulu as represented by its mountain and valley features is to a large extent reflected in the immediate under crust, and that a vast number of thrust and shear planes splitting up the old rocks of that area descend into that crust and are linked up with others which ultimately combine with the one or more that was the seat of the original earthquake. On that supposition the larger number of recorded shocks in Kulu becomes a normal and intelligible phenomenon.

Continuing our scrutiny of the list, we find that the severe or smart shock (accompanied by a rumbling) of October 7th at Bajaura in Kulu given as 8 P.M. was picked up by both the instruments in Simla. The same happened with the shock of October 14th, given as 5-40 A.M. at Bajaura, and 5-55 A.M. at Simla on the one instrument, and 6-13 A.M. on the Omori seismograph. Again on October 17th we have the same thing, the shock being also recorded from Mussoorie. On October 20th a shock felt in Simla and recorded by the two seismographs was also felt at Naggar. On the 23rd another, not felt, was similarly recorded at Simla and Naggar. In this way the records go on with occasional agreements between the distant stations to the end of the year, and with an occasional sharper one such as that of November 23rd felt between 3 and 4 A.M. at Bajaura, and also recorded at Simla, Dehra Dun and Rurki.

Frequency indicated since April 11th.

Looking back as far as April 11th, where, as already explained, the records first begin to be sufficiently clear for the identification of individual shocks, we find that in early April the average was about 7 separate shocks per day and that this gradually diminished until by the end of the year rather less than 1 shock per day is recorded.

On January 24th, 1906, the ordinary record of aftershocks from the Kulu and Simla areas was interrupted by a sharp shock felt at Lahore, which made many people rush out of their houses, and was preceded by a prolonged rumble. This shock was not recorded elsewhere and must have been local. On January 29th, Shahpur (Kangra District), Simla, and Holta (Palampur) recorded a shock about the same time. February 2nd is remarkable for the 3 or 4 shocks recorded by the two seismographs in Simla, but on February 28th we are introduced to an aftershock with its probable centre in the Simla Hill Tracts or Kulu that by itself would rank as a very respectable earthquake.

Bashahr aftershock, or secondary earthquake, of February 28th. 1906.

It was felt strongly over most of the meizoseismal area of the earthquake of 4th April, and was even recorded from Jaipur as well as from Montgomery, Agra, Dera Ismail Khan and Cherat. I am indebted to Mr. Calvert, Assistant Commissioner of Kulu, for details experienced by himself in the neighbourhood of the epicentral area. He was at Larji in Kulu at the time, and about 1 A.M. he felt a strong prolonged shock lasting about 1 minute. So far as he could recollect it was the worst shock since April 4th, though some people think the shock of 28th June was as bad. The great shock was followed by several smaller ones which he noticed until he fell asleep. Later in the day he went to Banjar (midway between Manglaur and Jibhi) and found there that the shocks were occurring on an average of 5 an hour, and continued throughout the 28th. Some were mere rumbles and others sharp shocks. Next day, 1st March, they occurred at the rate of about 2 per hour. At Bajaura on the same day he found these shocks were not noticeable, but on returning on the 2nd March to Banjar he found them still continuing at the average rate of about 1 per hour, and they were still continuing on the 3rd.

From the above, and from numerous telegrams appearing in the newspapers, all of which together with other information officially supplied are summarised in the list under the date 28th February, it is clear that this destructive aftershock was the worst that had occurred up to date, and in a restricted sense might be regarded as a separ-

ate earthquake. Besides the accounts of damage done to buildings and the loss of life over a large area, the shock was of sufficient severity and individual character to be followed by a set of its own after-shocks. The seismographs of Simla alone were kept very busy for hours and days recording these, until in their case and in that of other parts of the area these derivative or secondary aftershocks became gradually merged and confused with the general series of ordinary primary aftershocks.

As in the case of the earthquake of 4th April the local times accorded to this shock vary enormously. Many of the wilder parts of the hills could hardly be expected to furnish very accurate returns; consequently, just as was the case with the big shock of 4th April, the recorded times of this which must have been one approximately simultaneous shock are spread out over at least 1½ hours, namely, from midnight to 1-30 A.M. Nevertheless it is instructive to see that the times recorded at the larger and more important towns such as Lahore, Chakrata, Dehra Dun, Simla, Rurki, Sialkot, Palampur and Saharanpur are very close to those recorded by the Simla seismographs, none of them being more than 2 or 3 minutes out—a fact which confirms our speculations on the comparative reliability of the recorded times of the original shock of 4th April as received from important and unimportant towns respectively (see p. 285).

The shock appears to have been certainly recorded by the Milne seismograph at Alipore, Calcutta, where the figures given are in standard time :—Commencement of preliminary tremors 1H. 15·8M. Maxima 1H. 19·9M. Duration 1H. 11·2M. and maximum amplitude measured from the base line 14·00mm. Unfortunately these figures cannot be compared with the Simla ones because of the query mark attached to those furnished by the Omori-Ewing instrument.

The intensity of this shock at the epicentrum in the neighbourhood of Rampur in Bashahr and the Saraj tehsil of the Kangra District must have been about IX of the Rossi-Forel scale judging by the damage done and the loss of life to men and animals. The position is noticeably near the E.S.E. end of the meizoseismal area of the big

earthquake where it touches the Sutlej valley, and it may represent a more near-the-surface rupture possibly continuous with the axial centrum of that earthquake.

The fact of the secondary aftershocks being so much more pronounced in this direction than at Bajaura and elsewhere in Kulu and Kangra also indicates that the actual centrum of the big aftershock has exhibited in this case well-marked migration to the E.S.E. and upwards from the general position of the grand centrum of the disaster of 4th April.

After the 3rd March the frequency of the aftershocks sink to about 1 a day towards the end of the month. In April and May the aftershock record returns to its normal state. On May 20th, 1906, occurred a moderately severe aftershock recorded from Mussoorie, Delhi, Dehra Dun, Lahore, Bijnor and Rurki. It was pronounced in the neighbourhood of Mussoorie, Dehra Dun and Rurki, where it was noticed by everyone, and doors and windows rattled and lamps swung. Although I have received no reports from the Kangra-Kulu area it is stated in the Monthly Weather Report to have been felt over a large part of Kashmir and at Skardu, Dras, Sonemarg and Leh. The larger waves were recorded at the Simla Observatory by the Omori-Ewing seismograph at 16H. 42·2M., the disturbance lasting 18·8 minutes. It does not appear to have affected the Alipur instrument, though a doubtful shock is recorded by the latter about an hour before. The only record for the latter part of May is a severe shock at Bajaura on the 26th followed by 3 milder ones on the 28th.

On June 13th at 11·15 P.M., as given in the Omori seismograph record at Simla, there was a sharp to severe shock lasting 3 or 4 seconds described from Simla as the worst since the 28th February 1906. The Imperial Secretariat buildings on Gorton Hill were slightly damaged and many natives spent the night in the open. At Bajaura it was felt severely, and every one ran out of doors alarmed. At Dehra Dun it was smart, rather severe at Seharanpur and felt also at Chakrata and Meerut. At Mussoorie a shock about the same

time of day but given as the 14th (doubtless by mistake) was noticed by a great number of people and doors rattled and houses shook.

On June 18th and 21st occurred shocks felt jointly in Kulu and the Simla-Dehra Dun areas. On the latter date at later hours also occurred local shocks at Mount Abu (Rajputana).

On July 21st was the next severe shock at 1·57 A.M. as given by the Omori seismograph at Simla, and felt as a smart shock at Bajaura, Naggar, Dehra Dun, Kashmir, Rawal Pindi, Lahore, Mussoorie, besides being reported from Delhi and Dalhousie and a wide area in the Western Himalayas. This shock is remarkable as having been severe at Kangra and lasting 5 to 10 seconds. It is seldom that aftershocks have been recorded from Kangra. This may be partly because of the absence of observers there, but it may also be because the original earthquake of 4th April did its work so well that no subsequent settlements at that part of the axial centrum were generally necessary. On the other hand the more numerous and severe aftershocks that have been recorded from the opposite and deeper end of that centrum in Kulu, point it out as being generally unsatisfied by the original quake especially as regards the more near the surface layers above it, which took a long time to work off their secondary conditions of irregular strain resulting from the first deep-seated discharge. The shock of the 21st was recorded by the Barrackpore (near Calcutta) H. F. Magnetograph at 2H. 3M. 45S. standard time, according to a note kindly furnished me by Capt. Thomas, R.E., who also felt the tremor personally.

August is not remarkable for many aftershocks from our area, but elsewhere seismicity was active : on the 16th, Rajputana was shaken about 3-45 A.M. followed by 3 later shocks recorded on the same day at Mount Abu. The 17th was the day of the big Valparaiso world-shake and there was one recorded from Assam on the 31st.

September and October were equally uneventful, November and December provided a more numerous crop of aftershocks recorded in Kulu and Simla, but without many of them being synchronous,

With the year 1907 comparative quiescence sets in and the few shocks recorded more and more lose the aspect of genuine aftershocks. We continue to have records from the Simla seismographs and from Kulu which occasionally synchronise ; but only very seldom, as the shock of 13th April, are there any reports from outside of this region.

Although it is probable that the hilly region of Kulu and Simla will go on yet for some time yielding shocks that may have a connection with the big shock of 4th April 1905, yet as time goes on these will be confused with local ones common to the region and distant ones from other centres. No more reports therefore were asked for after December 1907 unless anything out of the common occurred. The Kelvin Grove seismoscope continued recording up to the end of April 1908.

List of Aftershocks.

[NOTE.—The times recorded in the list of aftershocks have all been converted into Indian Railway time whenever the standard used by the observer was known. For the first part of the list up to July 1905, such railway time was that of the longitude of Madras which is 5H. 20M. 59·2S. (for convenience taken as 5H. 21M.) east of Greenwich. After that date railway time was officially changed to so called "Standard Indian Time" which is taken as 5H. 30M. east of Greenwich.]

Date.	Time and details of shocks.	Place.
1905, April 4th	4 shocks between 6 and 7 A.M.	Ranikhet.
" "	Tremors up to 3 P.M.	Srinagar, Kashmir.
" "	Not less than 13 in 12 hours after main shock.	Hoshiarpur.
" "	3 or 4 during the day	Kousanie.
" "	Between 6 and 10 A.M., 4 shocks	Simla.
" "	6-5 to 6-35 A.M., 4 shocks each 10—20 secs.	Tehri, Garhwal.
" "	6-8 A.M. ($\frac{1}{3}$ min.)	Thanesar (Karnal).
" "	6-9$\frac{1}{3}$ A.M., main shock	Meteor. Obsy., Simla.
" "	6-9$\frac{1}{3}$—8-14 A.M., intermittent	Meteor. Obsy., Simla.
" "	About every $\frac{1}{2}$ hour	Nagar.
" "	6 shocks up to 3 P.M., mild	Panipat, Karnal Dist.
" "	6-10 to 7 A.M., 2-3 slight shocks	Rurki.
" "	Between 6-10 and 8 A.M., 3 or 4 shocks.	Sialkot.
" "	Between 6-10 and 9-45, at irregular intervals.	Lahore.
" "	From 6-10 to 10-30 A.M., 9 shocks	Ludhiana.
" "	Between 6-10 and 11-45 A.M.	Dehra Dun.
" "	Few minutes after main shocks	Ranikhet.
" "	Few minutes after 6-10 A.M.	Kaithal (Karnal Dist.)
" "	6-15 A.M.	Srinagar, Garhwal.
" "	6-15 A.M.	Pauri.
" "	6-15 A.M.	Dehra Dun.
" "	Between 6-15 and 7 A.M., 3 smart and 1 feeble.	Mussoorie.
" "	6-15 to 10-30 A.M., 7 shocks	Ferozepur.
" "	6-18 A.M.	Lansdowne.
" "	6-19 A.M., severe	Lahore.
" "	6-20 A.M.	Phillour (Jullundur).
" "	6-20 A.M.	Pauri.
" "	6-20 A.M., very slight	Pathri near Hardour.
" "	6-20 to 6-20-30 A.M.	Delhi.
" "	6-25 A.M.	Ranikhet.
" "	6-25 A.M. (about), distinct	Rurki.
" "	6-20—6-25 A.M.	Rosa, Shajahanpur Dist.

Date.	Time and details of shocks.	Place.
1905, April 4th .	Between 6-20--7-45 A.M., 4 or 5 shocks.	Mussoorie and Landour.
" " .	6-21 Mag. H. F.	Dehra Dun.
" " .	6-22 (nearest minute) . . .	Deodhur, Jagdhri Tehsil (Umballa).
" " .	6-22 A.M.	Pathri near Hardwar.
" " .	6-23 A.M.	Lansdowne.
" " .	6-25 A.M.	Pauri.
" " .	6-25 A.M. (2 secs.) . . .	Karnal.
" " .	6-25—6-26-15 A.M. . . .	Delhi.
" " .	6-25 to 8-0 A.M., 3 shocks . .	Saharanpur.
" " .	6-27 A.M.	Pathri near Hardwar.
" " .	6-28 A.M. 5 secs., rumbling noise and shock.	Naini Tal.
" " .	6-29 Mag. H. F.	Dehra Dun.
" " .	6-29 A.M. (2 or 3 secs.) . . .	Rupar (Amballa).
" " .	6-30 A.M.	Pindri (Karnal Dist).
" " .	6-30 A.M.	Phagwara (Kapurthala).
" " .	6-30 A.M.	Bazpur, Naini Tal Dist.
" " .	6-30 A.M.	Phillour.
" " .	6-30 A.M.	Muzaffarnagar.
" " .	6-30 A.M. (about), very light . .	Chirawa, Jaipur Dist.
" " .	6-30 A.M., hardly felt . . .	Aligarh, United Provs.
" " .	6-30 A.M., very slight . . .	Amroha, Moradabad.
" " .	6-30 A.M. (4 secs.)	Phagwara (Jullundur Dist.).
" " .	6-30 A.M.	Gurdaspur.
" " .	6-30 A.M., slight (1 min.) . . .	Babugarh, Meerut Dist.
" " .	6-30 A.M.	Dehra Dun.
" " .	6-30 A.M.	Jullundar.
" " .	Between 6-30--7-0 P.M. . .	Patiala.
" " .	6-31 Mag. H. F., also felt . .	Dehra Dun.
" " .	6-33 A.M. (nearest minute) . .	Deodhur.
" " .	6-33 A.M.	Landsdowne.
" " .	6-35 A.M., hardly felt . . .	Meerut.
" " .	6-35 A.M. (2 secs	Karnal.
" " .	6-35 A.M., slight)	Naini Tal.
" " .	6-35 A.M.	Muzaffarnagar.
" " .	6-35 A.M.	Tanda (Gujrat).
" " .	6-37 Mag. H. F.	Dehra Dun.
" " .	6-38 A.M. (nearest minute) . .	Deodhur.
" " .	6-40 A.M.	Kartarpur.
" " .	6-40 A.M., severe	Amballa.
" " .	6-40 A.M.	Pauri.
" " .	6-40 A.M. (about), slight . . .	Bharatpur, Rajputana.

Date.	Time and details of shocks.	Place.
1905, April 4th	6-40 A.M.	Dehra Dun.
" "	6-43 A.M., mild	Chor peak, Sarain Obsy.
" "	6-45 A.M., slight	Moradabad, United Provs.
" "	6-45 A.M.	Bhim Tal, Naini Tal Dist.
" "	6-45 A.M.	Jagraon, Ludhiana.
" "	6-45 A.M., not severe	Muktesar, Naini Tal Dist.
" "	6-45 A.M. (about), distinct	Rurki.
" "	6-46 Mag. H. F. also felt	Dehra Dun.
" "	6-47 A.M. (nearest minute)	Deodhur.
" "	6-50 A.M., slight	Between Pathri and Rurki.
" "	6-50 A.M. (3 secs.)	Karnal.
" "	6-50 A.M.	Rambagh, Dehra Dun Dist., United Provs.
" "	6-55 A.M., distinct	Rurki.
" "	6-55 A.M.	Dehra Dun.
" "	6-55 A.M. (about, 15 secs.)	Mussoorie and Landour.
" "	6-55 A.M., rather severe	Srinagar, Kashmir.
" "	6-55 A.M. (duration 30 secs.)	Almora, United Provinces.
" "	6-55 A.M. (12 secs.)	Nálapani Camp.
" "	6-55 A.M., hardly felt	Meerut.
" "	6-58 A.M.	Lansdowne.
" "	6-58 A.M.	Dehra Dun.
" "	6-58 E.—W.	Dhakauli, Meerut Dist.
" "	6-59 A.M. (50 secs. N.—S.)	Rurki.
" "	7 A.M.	Dhariwal, Gurdaspur.
" "	7 A.M.	Meerut.
" "	7 A.M. (3 or 4 secs.)	Rohtak.
" "	7 A.M. (5 secs.)	Sardhana, Meerut.
" "	7 A.M., slight	Khanki (Gujranwala).
" "	7 A.M.	Nakadar (Jullundur Dist.)
" "	7 A.M., light	Bijnor.
" "	7 A.M., distinctly felt	Chamba.
" "	7 A.M., slight	Naini Tal
" "	7 A.M. (25 secs.)	Tehri, Garhwal.
" "	7 A.M.	Kartarpur (Jullundur).
" "	7 A. ., fairly severe.	Sialkot.
" "	7 A.M., slight	Faridkot.
" "	About 7 A. M.	Sirsa (Hissar).
" "	7 A.M.	Chamba (Hazara).
" "	7 A.M.	Jalalpur Jattan (Gujrat Dist.)

Date.	Time and details of shocks.	Place.
1905, April 4th .	Between 7 A.M. and 2 P.M., 4 or 5 shocks.	Sangrur (Jhind State).
" " .	7-2 A.M., distinctly felt . . .	Meerut.
" " .	7-3 A.M., not severe . . .	Muktesar, Naini Tal Dist.
" " .	7-3 A.M.	Bhim Tal, Naini Tal Dist.
" " .	7—7-5 A.M.	Mashobra.
" " .	7-5 A.M. (3 mins.)	Jawalapur, Saharanpur Dist.
" " .	7-10 A.M.	Ranikhet.
" " .	7-10 A.M.	Kartarpur.
" " .	7-10 A.M.	Naini Tal.
" " .	7-10 A.M. (nearly)	Gurdaspur.
" " .	7-10 to 7-15 A.M., hardly felt . .	Kosi, Muttra Dist. United Provs.
" " .	7-15 A.M.	Nakadar.
" " .	7-15 A.M.	Tanda (Gujrat).
" " .	7-20 A.M.	Jagraon.
" " .	7-28 A.M., mild . . .	Sarain Obsy., Chor.
" " .	7-30 A.M., 15 secs. duration . .	Najibabad, United Provinces.
" " .	7-30 A.M. (exact) 10 secs. . .	Mussoorie and Landour.
" " .	7-30 A.M., slight	Moradabad.
" " .	7-30 A.M. (about)	Amritsar.
" " .	7-30 A.M. about	Sangrur (Jhind State).
" " .	7-35 A.M., mild	Sarain Obsy., Chor.
" " .	7-35 A.M.	Pauri.
" " .	7-35 A.M.	Nakadar.
" " .	7-37 A.M.	Pauri.
" " .	7-39 A.M., Mag. H. F. . . .	Dehra Dun.
" " .	7-40 A.M.	Nalapani Camp.
" " .	7-45 A.M.	Dwarahath, Kumaun Dist.
" " .	7-51 Mag. H. F., also felt . .	Dehra Dun.
" " .	7-55 A.M. 1 min.	Naini Tal.
" " .	8 A.M.	Mussoorie and Landour.
" " .	8 A.M. (about)	Amritsar.
" " .	8 A.M. 10 secs.	Tehri, Garhwal.
" " .	8 A.M., slight	Khanki (Gujranwala).
" " .	Between 8 and 9 A.M.	Hissar.
" " .	8-10 A.M.	Amritsar.
" " .	8-15 A.M.	Pimdrí.
" " .	8-30 A.M. 10 secs.	Tehri, Garhwal.
" " .	8-30 A.M.	Nagína.
" " .	8-30 A.M.	Kanaud (Patiala State).
" " .	8-30—10-10 A.M., 3 shocks, 5-10 secs.	Tehri, Garhwal.
" " .	8-44—8-54 A.M.	Mashobra.

Date.	Time and details of shocks.	Place.
1905, April 4th	8-50 A.M.	Phillour.
,, ,,	8-56 Mag. H. F.	Dehra Dun.
,, ,,	9 A.M., smart	Mussoorie.
,, ,,	9 A.M.	Bulandshahr, United Provinces.
,, ,,	9 A.M.	Jagraon.
,, ,,	9 A.M., slight	Faridkot.
,, ,,	9 A.M. (about)	Hardwar, Saharanpur.
,, ,,	9 A.M.	Barkot, Dehra Dun District.
,, ,,	9 A.M. (about)	Amritsar.
,, ,,	9-4 Mag. H.F.	Dehra Dun.
,, ,,	9-10 A.M. (1 min., slight)	Kairana, Muzaffarnagar, United Provinces.
,, ,,	9-10 A.M.	Dhariwal.
,, ,,	9-25 A.M. ($\frac{1}{2}$ min.)	Thanosar.
,, ,,	9-30 A.M. (15 secs.)	Do.
,, ,,	9-30 A.M.	Phagwara.
,, ,,	9-30 A.M.	Phagwara (Kapurthala)
,, ,,	After 9-30 A.M. (slight)	Jullundur.
,, ,,	9-30 A.M.	Amritsar.
,, ,,	9-30 A.M.	Ferozepur.
,, ,,	9-45 A.M. (last one)	Almora.
,, ,,	9-50 A.M.	Simla.
,, ,,	10 A.M.	Dehra Dun.
,, ,,	10 A.M.	Srinagar, Kashmir.
,, ,,	10 A.M.	Jagraon.
,, ,,	10 A.M.	Gujranwala.
,, ,,	10 A.M. (30 secs. duration)	Ramnagar (Gujranwala).
,, ,,	10 A.M., slight	Khanki.
,, ,,	10 A.M.	Amritsar.
,, ,,	10 A.M., very slight	Amballa.
,, ,,	10 A. M.	Garhmuktesar, Meerut Dist.
,, ,,	10 A.M. (2 secs. duration)	Ramnagar (Gujranwala).
,, ,,	10 A.M.	Meerut.
,, ,,	10 A.M.	Bijnor.
,, ,,	10-10 A.M.	Dagshai.
,, ,,	10-15 A.M., most severe (2 separate	Bikaner.
,, ,,	local shocks).	
,, ,,	10-15 A.M., slight	Nowshera (Sialkot District).
,, ,,	10-15 A.M. about	Mussoorie and Landour.
,, ,,	10-15 A.M., 15 secs.	Najibabad.
,, ,,	10-22 A.M.	Kotla near Ferozebad, Agra District.

Date.	Time and details of shocks.	Place.
1905, April 4th	10-30 A.M.	Dehra Dun.
" "	10-30 A.M. (about)	Amritsar.
" "	10-30 A.M.	Do.
" "	10-30 A.M.	Rurki.
" "	10-30 A.M. hanging lamp N - S.	Naini Tal.
" "	10-30 A.M.	Simla.
" "	10-30 A.M., 30 secs	Rurki.
" "	10-30 A.M.	Gujranwala.
" "	10-30 A.M., very slight	Rurki.
" "	10-30 A.M.	Simla.
" "	10-30 A.M 8-9 secs.	Ferozepur.
" "	10-30 A.M.	Kanaud (Patiala State).
" "	10-30 A.M. } 10-40 A.M. } 3 mins.	Rurki.
" "	10-31 A.M., 4 secs.	Tehri, Garhwal.
" "	10-35 A.M.	Pauri.
" "	10-37 A.M., 3 secs.	Tehri, Garhwal.
" "	10-37 A.M.	Dehra Dun.
" "	10-40 A.M.	Srinagar, Garhwal.
" "	10-40 A.M., felt	Dehra Dun.
" "	10-45 A.M.	Mussoorie and Landour.
" "	10-45 A.M. (mild)	Sarain Obsy., Chor.
" "	Between 11 A.M. and 2 P.M., 5 shocks	Dadupur (Amballa).
" "	11 A.M. (about)	Mussoorie and Landour.
" "	11 A.M.	Barkot, Dehra Dun Dist.
" "	11 A.M.	Mussoorie and Landour.
" "	11 A.M.	Tanda (Gujarat).
" "	11 A.M.	Meerut.
" "	11 A.M. (about)	Amritsar.
" "	11 A.M., 1 sec., slight	Kairana Muzaffarnagar.
" "	11 A.M.	Saharanpur.
" "	11 A.M., smart	Mussoorie.
" "	11 A.M.	Kartarpur (Jullundur).
" "	11-10 A.M. 5 mins.	Jawalapur, Saharanpur Dist.
" "	11-15 A.M.	Pundri.
" "	11-15 A.M.	Mussoorie and Landour.
" "	11-30 A.M.	Dehra Dun.
" "	11-30 A.M.	Sardhana, Meerut.
" "	11-30 A.M., slight	Sakandrabad (Bulandshahr).
" "	11-40 P.M., mild	Sarain Obsy., Chor.
" "	11-45 A.M.	Simla.
" "	11-50—11-54 A.M.	Mashobra.
" "	11-58 A.M., 45 secs. with great rumbling	Rurki.
" "	12 noon, 15 secs.	Nalapani Camp.

Date.	Time and details of shocks.	Place.
1905, April 4th	12 noon	Gujranwala.
" "	12 noon	Kaithal (Karnal Dist.)
" "	12 noon	Amritsar.
" "	12 noon	Gurdaspur.
" "	12 noon (very slight)	Amballa.
" "	12 noon	Simla.
" "	12 noon	Rohtak.
" "	12-30 (afternoon)	Pimdri.
" "	12-30 P.M. (10 secs).	Najibabad.
" "	1 P.M.	Ferozepur.
" "	1 P.M., light	Bijnor.
" "	1 P.M. (and others afterwards)	Chamba (Hazara).
" "	13 distinctly felt	Chamba.
" "	1-30 P.M.	Kartarpur.
" "	1-30 P.M.	Pegan Chowki, 36 miles S.W. by W. of Karnal.
" "	1-30 P M. (about)	Amballa.
" "	1-30 P.M.	Sardhana Meerut.
" "	1-30 P.M.	Saharanpur.
" "	1-30 P.M., 2 shocks	Ferozepur.
" "	Between 1-30 and 2 P.M. rather severe.	Amballa.
" "	13-35, 1½ mins.	Tehri, Garhwal.
" "	1-40 P.M.	Jalalpur Jattar (Gujrat Dist.)
" "	13-41 Mag. H. F.	Dehra Dun.
" "	1-44 P.M., 8-9 secs.	Ferozepur.
" "	1-45 P.M. (violent like first)	Sarain Obsy., Chor.
" "	13-45	Simla.
" "	1-50 P.M., slight	Faridkot.
" "	1-50 P.M.	Muzaffarnagar.
" "	13-50 (2 secs.)	Karnal.
"	13-55	Pimdri.
" "	1-55 P.M.	Pauri.
" "	13-55	Phillour.
" "	13-55, slight	Jullundur.
" "	1-58 P.M.	Mussoorie and Landour
" "	1-58 P.M.	Dehra Dun.
" "	13-59 Mag. H. F., also felt	Do.
" "	2 P.M., smart	Mussoorie.
" "	2 P.M.	Dehra Dun.
" "	2 P.M.	Meerut.
" "	2 P.M., distinctly felt	Do.
" "	2 P.M.	Nalapani Camp.
" "	14-0 (very slight)	Amballa.
" "	2 P.M., not severe	Do.
" "	2 P.M.	Kartarpur.
" "	2 P.M.	Rurki.

Date.	Time and details of shocks.	Place.
1905, April 4th	2 P.M.	Ranipur, 2 miles from Jawalapur, Saharanpur Dist.
,, ,,	2 P.M., slight	Rurki.
,, ,,	2 P.M., 30 secs. N.E.—S.W.	Do.
,, ,,	2 P.M. (about)	Hardwar.
,, ,,	2 P.M. fairly severe	Do.
,, ,,	2 P.M., 5 secs.	Rurki.
,, ,,	2 P.M.	Phagwara (Kapurthala).
,, ,,	2 P.M.	Simla.
,, ,,	14-0	Thanesar.
,, ,,	2 P.M. mild	Sarain Obsy., Chor.
,, ,,	(2—3) P.M.	Shahpur (Kangra Dist.)
,, ,,	14-2 P.M., 1 sec.	Muzaffarnagar.
,, ,,	2-2 P.M.	Dehra Dun.
,, ,,	14-5	Jagraon.
,, ,,	2-5 P.M., slight, ½ min.	Ranikhet.
,, ,,	2-5 P.M., 15 secs.	Do.
,, ,,	2-10 P.M.	Mussoorie and Landour.
,, ,,	14-45, 10 secs.	Najibabad.
,, ,,	3 P.M.	Amballa.
,, ,,	15-0, 3 mins.	Jawalapur, Saharanpur District.
,, ,,	3 P.M.	Gujranwala.
,, ,,	3-15 P.M.	Nalapani Camp.
,, ,,	3-30 P.M.	Patiala.
,, ,,	3-30 P.M.	Pegan Chowki.
,, ,,	3-30 P.M.	Mussoorie and Landour.
,, ,,	3-30 P.M., mild	Sarain Obsy. Chor.
,, ,,	15-30, 30 secs.	Tehri, Garhwal.
,, ,,	3-40 P.M., slight	Faridkot.
,, ,,	3-45 P.M., distinct	Rurki.
,, ,,	3-50 P.M.	Amballa.
,, ,,	3-50 P.M.	Dehra Dun.
,, ,,	15-50 Mag. H.F., also felt	Do.
,, ,,	3-50 P.M., 6 secs.	Nalapani Camp.
,, ,,	3-50 P.M.	Simla.
,, ,,	16-0, very slight	Amballa.
,, ,,	4 P.M.	Amritsar.
,, ,,	4 P.M.	Dadupur (Amballa).
,, ,,	4 P.M.	Dehra Dun.
,, ,,	4 P.M.	Ferozepur.
,, ,,	4 P.M., smart	Mussoorie.
,, ,,	4 P.M.	Mussoorie and Landour.

Date.	Time and details of shocks.	Place.
1905, April 4th	4 P.M.	Nagina.
" "	16-0	Pimdri.
" "	4 P.M., slight	Rurki.
" "	4 P.M.	Sialkot.
" "	4-1 P.M.	Dehra Dun.
" "	4-5 P.M.	Dagshai.
" "	4-7 P.M.	Dehra Dun.
" "	16-10, 5 secs.	Najibabad.
" "	4-10 P.M., 2 or 3 secs.	Rupar.
" "	4-15 P.M.	Tanda (Gujrat).
" "	16-30, 2 mins.	Jawalapur, Saharanpur District.
" "	5 P.M., slight	Faridkot.
" "	5 P.M. (about)	Gurdaspur.
" "	5 P.M., very slight	Poonch, Kashmir.
" "	17-15, 10 secs.	Najibabad.
" "	17-30	Jagraon.
" "	5-30 P.M., very slight	Ludhiana.
" "	5-38 P.M.	Amballa.
" "	5-40 P.M., mild	Sarain Obsy., Chor.
" "	5-45 P.M.	Chari, near Dharmsala.
" "	17-45	Simla.
" "	17-50	Pimdri.
" "	17-55 Mag. H.F.	Dehra Dun.
" "	18-0, very slight	Amballa.
" "	6 P.M.	Dehra Dun.
" "	6 P.M., 2 shocks	Ferozepur.
" "	18-0, 15 secs.	Tehri, Garhwal.
" "	About 18 (severe)	Meteor. Obsy., Simla.
" "	6 P.M.	Simla.
" "	6 to 6-5 P.M.	Mashobra.
" "	6-5 P.M.	Dhariwal.
" "	18-20, 3 mins.	Jawalapur, Saharanpur District.
" "	9 P.M.	Tanda (Gujrat).
" "	18-30 Mag. H. F.	Dehra Dun.
" "	18-30, 15 secs. N.-S.	Najibabad.
" "	7-30 P.M.	Dehra Dun.
" "	20-2	Thanesar.
" "	20-15, 3 mins.	Jawalapur, Saharanpur District.
" "	9 P.M.	Tanda (Gujrat).
" "	21-59 Mag. H. F.	Dehra Dun.
" "	22-0, 3 mins.	Jawalapur, Saharanpur District.
" "	22-0, slight	Jullundur.
" "	10 P.M.	Phagwara (Kapurthala).

Date.	Time and details of shocks.	Place.
1905, April 4th	10-30 P.M.	Kapurthala.
,, ,,	10-30 P.M., 2 or 3 secs.	Rupar.
,, ,,	10-40 A.M.	Amritsar.
,, ,,	10-50 P.M.	Solan (Baghat Dist.).
,, ,,	11 P.M., sharp like a downward crash	Khanki.
,, ,,	11 P.M., very slight	Poonch, Kashmir.
,, ,,	11 P.M.	Ranipur, 2 miles from Jawalapur, Saharanpur District.
,, ,,	11 P.M., slight	Dalhousie (Gurdaspur).
,, ,,	11 P.M.	Dera Ghazi Khan.
,, ,,	11 P.M.	Dhariwal.
,, ,,	11 P.M.	Srinagar, Garhwal.
,, ,,	11 P.M., slight	Hardwar.
,, ,,	11-25 P.M.	Solan (Baghat Dist.).
,, ,,	11-30 P.M., slight	Bijnor.
,, ,,	11-30 P.M.	Dadupur.
,, ,,	23-30, 7 secs.	Tehri, Garhwal.
,, ,,	11-30 P.M. (about), rather intense	Hardwar.
,, ,,	23-30, 2 secs.	Karnal.
,, ,,	11-30 P.M., very slight	Ludhiana.
,, ,,	11-30 P.M. to 1-15 A.M. on 5th, periodic disturbances of varying intensity.	Rurki.
,, ,,	11-40 P.M.	Phagwara (Kapurthala).
,, ,,	11-45 P.M.	Dadupur.
,, ,,	11-45 P.M.	Solan (Baghat Dist.)
,, ,,	23-45	Thanesar.
,, ,,	23-50	Pimdri.
,, ,,	23-50, sharp	Rurki.
,, ,,	11-50 P.M.	Dehra Dun.
,, ,,	11-53 P.M.	Do.
,, ,,	11-55 P.M., slight	Sikanderabad.
,, ,,	23-55, 1 sec.	Muzaffarnagar.
,, ,,	11-55 P.M.	Nalapani Camp.
,, ,,	11-55 P.M.	Pauri.
,, ,,	11-55 P.M., slight	Moradabad.
,, ,,	11-55 P.M., 20 secs.	Nalapani Camp.
,, ,,	23-57 Mag H. F. also felt	Dehra Dun.
,, ,,	11-57 P.M.	Deoband, Saharanpur Dist.
,, ,,	11-57 P.M.	Dehra Dun.
,, ,,	11-58 P.M.	Rurki.
,, ,,	12 P.M. midnight, intense	Mussoorie and Landour.
,, ,,	12 midnight	Amballa.
,, ,,	12 ,,	Kaithal (Karnal Dist.).
,, ,,	12 ,,	Rohtak.

Date.	Time and details of shocks.	Place.
1905, April 4th .	12 Midnight, severe . . .	Mussoorie.
,, ,, .	12 P.M. (10 secs. mild) . . .	Panipat, Karnal Dist.
,, ,, .	12 midnight	Rurki.
,, ,, .	12 ,, (distinctly felt) . .	Meerut.
,, ,, .	12 ,, slight	Moradabad.
,, ,, .	12 ,, ...	Muzaffarnagar.
,, ,, .	12 ,, (not severe). . .	Amballa.
,, ,, .	12 ,, (1 sec.) . . .	Ramnagar, Gujranwala.
,, ,, .	12 ,, ...	Garhmuktesar, Meerut Dist.
,, ,, .	12 P.M.	Rambagh, Dehra Dun Dist., U. P.
,, ,, .	12 midnight, guessed 4 secs. . .	Sardhana, Meerut.
,, ,, .	12 ,, ...	Dehra Dun.
,, ,, .	24	Thanesar.
,, ,, .	12 P.M. midnight	Amritsar.
,, ,, .	12 midnight	Mussoorie and Landour.
,, ,, .	At night 2 shocks	Amritsar.
,, ,, 4—5th	Midnight, severe	Saharanpur.
,, ,, .	Twice in night	Delhi.
,, ,, .	12-30 after midnight . . .	Jhajjar, Rohtak Dist. (Panjab).
,, ,, .	(10 P.M. to 4 A.M., 4 slight shocks) .	Faridkot.
,, ,, .	Midnight	Delhi.
,, ,, 4—9th	Rate decreased to 8 to 12 shocks in 24 hours.	Naggar.
,, ,, 4th — May 19th.	Day and night at various intervals and intensity.	Bajaura (Kula).
1905, April 5th .	2 A.M. (2 secs.)	Karnal.
,, ,, .	2 A.M.	Ramnagar (Gujranwala).
,, ,, .	2 A.M., severe	Mussoorie and Landour.
,, ,, .	2-30 A.M. (2 secs.)	Karnal.
,, ,, .	3 A.M. (10 secs., mild) . . .	Panipat, Karnal Dist.
,, ,, .	4 A.M.	Amritsar.
,, ,, .	6 A.M., slight	Dalhousie.
,, ,, .	7 A.M.	Thanesar.
,, ,, .	7-4 A.M. Mag. H. F. . . .	Dehra Dun.
,, ,, .	12 noon	Thanesar.
,, ,, .	2 P.M.	Mussoorie and Landour.
,, ,, .	2-30 P.M. ?	Rurki.
,, ,, .	3 P.M.	Thanesar.
,, ,, .	16	Do.
,, ,, .	9 P.M.	Shahpur (Kangra Dist.
,, ,, .	9-40 P.M.	Rurki.
,, ,, .	22-10, slight	Do.

Date.	Time and details of shocks.	Place.
1905, April 5th .	11 P.M. ?	Rurki.
" " .	11 P.M., fairly severe	Islamabad, Kashmir.
" " .	12 midnight, 2 other shocks . .	Ranikhet.
" " .	Loud noises like cannons . .	Bhajji State (Simla).
" " 5-6th	In night several	Meteorological Obsy. Simla.
" " 6th .	1-55 A.M., very slight . . .	Rurki.
" " .	2 A.M.	Do.
" " .	8-45 A.M.	Mussoorie and Landour.
" " .	21-21 Mag. H. F.	Dehra Dun.
" " .	10 P.M., 2 shocks	Mussoorie and Landour
" " .	Several tremors	Rurki.
" " 7th .	Loud noises like cannons . .	Bhajji State, Simla.
" " } " " 8th }	Continuous slight shocks . .	Kulu.
" " 9th } " " 10th } " " 11th }	Continuous slight shocks . .	Do.
" " 8th .	4-30 A.M.	Ludhiana.
" " .	10-43 A.M., 35 secs.	Rurki.
" " .	7 P.M. slight	Dalhousie.
" " 8—9th	Night, 2 or 3 slight shocks . .	Simla.
" " 9th .	2-10 A.M.	Faridkot.
" " .	3-5 A.M.	Do.
" " 10th .	6 A.M. 6 secs.	Rurki.
" " .	1-45 A.M., 3 or 4 secs. distinct movement.	Dehra Dun.
" " .	9-45 P.M.	20 miles from Jhelum R.
" " .	11 P.M., sharp	Simla.
" " 10-11th	In night, 2 slight	Meteorological Obsy., Simla.
" " 11th .	10-30 A.M.	Gurdaspur.
" " .	10-30 A.M. tremors	Simla.
" " .	10-30 A.M., severe	Mussoorie and Landour.
" " .	10-39 A.M.	Mussoorie and Landour.
" " .	10-47 A.M. Mag. H. F. . . .	Dehra Dun.
" " .	10-45 A.M.	Mussoorie and Landour.
" " .	About 11 A.M., feeble . . .	Mussoorie.
" " .	11 A.M., slight	Manglaur, Saharanpur District.
" " .	12 A.M.	Mandi.
" " .	12-11 afternoon	Meteorological Obsy., Simla.
" " .	1 P.M.	Lahore.

Date.	Time and details of shocks.	Place.
1905, April 11th	12 midnight	Lahore.
„ „ 12th	1-36 A.M. Mag. H. F.	Dehra Dun.
„ „	1-41 A.M. Mag. H. F.	Do.
„ „	10-30 A.M., several	Mussoorie and Landour
„ „	4 P.M.	Lahore.
„ „	7-39 P. M. a few people still sleep in the open.	Simla.
„ „	19-40, smart	Do.
„ „	20-21 Mag. H. F.	Meteorological Obsy. Simla.
„ „	20-30 Mag. H. F.	Dehra Dun.
„ „	21-2 Mag. H. F.	Do.
„ „	21-9 Mag. H. F.	Do.
„ „	10 P.M., severe	Do.
„ „	11 P.M.	Mussoorie and Landour.
„ „ 12—13	Night fresh shocks	Lahore.
„ „ 13th	2 A.M.	Simla.
„ „	About 4 A.M.	Hoshiarpur.
„ „	2 P.M., moderate, 3 secs.	Kulu.
„ „	8 P.M., moderate,	Do.
„ „	8-50 P.M., moderate	Do.
„ „	Night	Gujrat City.
„ „ 14th	4-17 A.M., 3 secs.	Dhadur, near Sibi (Baluchistan).
„ „	4-30 A.M. moderate, 2 secs.	Kulu.
„ „	11-25 A.M., moderate	Do.
„ „	5-30 P.M., moderate	Do.
„ „	6-30 P.M., slight, 2 secs.	Do.
„ „	7-30 P.M., moderate, 2 secs.	Do.
„ „	8-30 P.M., moderate, 2 secs.	Do.
„ „	9-5 P.M., moderate, 2 secs.	Do.
„ „ 15th	3-40 A.M., severe, 3 secs	Do.
„ „	4-10 A.M., slight	Do.
„ „	5-14 A.M., slight, 5 secs.	Do.
„ „	6 (about) A.M.	Mussoorie and Landour.
„ „	6 A.M., distinct, doors rattled.	Rurki.
„ „	6 A.M., worst since 4th April, 1905	Kulu.
„ „	6 A.M., severe	Mussoorie and Landour.
„ „	6-4 A.M.	Mussoorie and Landour.
„ „ 15th	6.15 A.M.	Muzaffarnagar.
„ „	8-21 A.M., slight, 2 secs.	Kulu.
„ „	10 A.M.	Lahore.
„ „	2 P.M.	Do.
„ „	Afternoon	Gurdaspur.

Date.		Time and details of shocks.	Place.
1905, April 15th		About 7 P.M.	Hoshiarpur.
,,	,,	7-20 P.M., moderate, 3 secs.	Kulu.
,,	,,	8 P.M., moderate, 3 secs..	Do.
,,	,,	10 P.M., moderate, 3 secs.	Do.
,,	,,	12 midnight, moderate, 3 secs.	Do.
,,	,,	4 A.M., severe, 3 secs.	Do.
,,	16th	6 A.M., slight	Muhammadpur.
,,	,,	1-55 P.M., moderate, 2 secs.	Kulu.
,,	,,	4-15 P.M., moderate, 2 secs.	Do.
,,	,,	10-10 P.M., moderate, 2 secs.	Do.
,,	,,	12 midnight, very slight	Manglaur, Saharanpur District.
,,	,,	Midnight., distinctly felt.	Dehra Dun.
,,	17th	12-30 A.M., severe	Mussoorie and Landour.
,,	,,	1-55 P.M., moderate, 3 secs.	Kulu.
,,	,,	4 P.M., moderate, 2 secs..	Do.
,,	,,	Night. severe shock	Do.
,,	,,	(Between 11—12 night)	Mussoorie and Landour.
,,	18th	(Between midnight and 1-5 A.M.)	Mussoorie and Landour.
,,	,,	1 A.M., severe	Mussoorie and Landour.
,,	,,	1 A.M., very slight	Manglaur, Saharanpur District.
,,	,,	6 A.M., severe, 3 secs.	Kulu.
,,	,,	6-10 A.M., moderate, 2 secs.	Do.
,,	,,	12-55 [? A.M. or P.M.] most severe	Mussoorie and Landour.
,,	,,	2-25 P.M., moderat	Kulu.
,,	,,	4 P.M., moderate	Do.
,,	,,	Night, 2 slight shocks	Do.
	,,	8 P.M.	Mussoorie and Landour.
,,	19th	0-55 not severe	Meteo. Obsy., Simla.
,,	,,	1 A.M., smart	Mussoorie.
,,	,,	1 A.M.	Mussoorie and Landour.
,,	,,	3 A.M.	Mussoorie and Landour.
,,	,,	Between 5 and 6 A.M.	Dhadur near Sibi (Baluchistan), 4 secs.
,,	,,	6 A.M., severe, 3 secs.	Kulu.
		14-15, very slight	Mastuj (Chitral).
,,	20th	Between 5 and 6 A.M., 4 secs.	Dhadur near Sibi (Baluchistan).
,,	23rd	3 A.M. slight	Meteo. Obsy., Simla.

Date.	Time and details of shocks.	Place.
1905, April 23rd .	? time	Gurdaspur.
,, ,, .	Early morning } . very sharp .	Dharmsala.
,, 24th .	9-15 . }	
,, ,, .	9-30 A.M.	Chamba.
,, 27th .	11 A.M.	Mandi.
,, ,, .	5 P.M.	Do.
,, ,, .	10-15 P.M., slight . . .	Simla.
,, ,, .	10-45 P.M.	Gujrat City.
,, ,, .	11 P.M., very slight . . .	Manglaur, Saharanpur District.
,, 28th .	About 7-30 A.M. slight . . .	Bala (Baluchistan).
1905, May 1st .	8 A.M.	Mandi.
,, 3rd .	7-45 A.M.	Do.
,, ,, .	12 noon, slight with dull thud and rock slip from head of Neogal Gorge.	Palampur.
,, ,, .	Afternoon, slight with dull thud and rock slip from head of Neogal Gorge.	Do.
,, ,, .	time ? with landslip from Triun Hill [reported by Major Lane.]	Dharmsala.
,, 7th .	3-30 A.M., feeble	Mussoorie.
,, ,, .	10-15 P.M., feeble	Do.
,, ,, .	11 P.M., sharp shock	Drang (Salt mines).
,, 7—8th.	Midnight, sharp preceded by rumble and thud from W. Sound woke me and bed swayed N.—S.	Dhelu.
,, 9th .	5 A.M., sharp	Kulu.
,, ,, .	12 noon about	Do.
,, 10th .	6 P.M., sharp shock	Drang (Salt mines).
,, ,, .	9 P.M.	Mandi.
,, 14th .	3 slight shocks during day . .	Kulu.
,, 15th .	2 P.M., slight at night	Do.
,, 16th .	2 slight shocks, night . . .	Do
,, ,, .	2 slight shocks, day	Do.
,, 18th .	3-15 P.M., smart N.—S. directions, preceded by dull distant roar from S.	Bajaura
,, 19th .	5-30 A.M., smart quiver, sound from S.	Do.
,, ,, .	7-15 A.M., feeble	Do
,, ,, .	Little after 2 P.M., sharp brief . .	Simla.
,, ,, .	3-25 or 3-48 P.M., smart prolonged shake, 2 secs. duration, loud rumble from S.	Sultanpur (Kulu).
,, ,, .	10-9 or 10-30 P.M., feeble . .	Sultanpur.
,, 22nd .	2-45 P.M., smart preceded by distant boom.	Sultanpur and Channi (Kulu).
,, ,, .	3 [P.M., severe (from N. N. W. — S. S. E.)	Bajaura.
	7-21 P.M., smart double shock preceded ½ sec. by deep boom.	Channi and Bajaura.

Date.	Time and details of shocks.	Place.
1905, May 22nd .	8 P.M., severe (from N. N. W.— S. S. E.)	Bajaura.
,, 27th .	? time, considerable earth tremor (*Pioneer*, 4th June).	Kangra Valley.
,, 28th .	8-45 A.M., very feeble . . .	Naggar.
,, ,, .	10 A.M., slight, 1½ seconds N.E.—S.W.	Deesa, Rajputana.
,, ,, .	4-5 P.M., smart N.– S. . . .	Naggar and Sultanpur
,, ,, .	5-40 P.M., slight	Simla.
,, 29th .	2-8 A.M., smart	Naggar.
,, ,, .	8-15 A.M., smart to slight . .	Do.
,, 30th .	2 A.M.	Naggar and Kulu.
,, ,, .	2-18 P.M. Madras time (Seis.), not felt	Simla.
,, ,, .	6-35 P.M., not felt (Seis.) . .	Do.
,, ,, .	8-30 P.M.	Sultanpur.
,, 31st .	0-21 A.M., felt (Seis.) . . .	Simla.
,, ,, .	5-54 A.M., not felt (Seis.) . . .	Do.
,, ,, .	3-8 P.M., not felt (Seis.) . . .	Do.
,, May—June	1 or 2 each day and night . .	Naggar.
,, June 1st .	7-8 A.M. Madras time, not felt (Seis.)	Simla.
,, ,, .	5-20 P.M., very slight W.—E. . .	Bajaura.
,, ,, .	11-12 P.M., felt (Seis.) . . .	Simla.
,, 5th .	1-7 A.M., felt (Seis.) . . .	Do.
,, ,,	(At night) slight	Mussoorie.
,, 6th .	7-45 or 8-15 P.M., sharp with deep rumble.	Jibhi (Kulu).
,, 7th .	8-14 A.M., not felt (Seis.) . .	Simla.
,, ,, .	12-47 P.M. (Seis.)	Do.
,, ,, .	3-20 P.M. (Seis.)	Do.
,, 8th .	6 A.M., sharp thud from below preceded by boom.	Kot (Kulu).
,, 9th .	1-50 A.M., slight, 4 secs., to and fro .	Dehra Dun.
,, 10th .	1-20 A.M., felt (Seis.) . . .	Simla.
,, ,, .	2 A.M., very severe, shook beds and house from E.	Naggar.
,, ,, .	10-34 A.M., not felt (Seis.) . .	Simla.
,, 11th .	2-2 A.M., felt (Seis.) . . .	Do.
,, 13th .	7 P.M., slight	Naggar.
,, ,, .	10 P.M., slight	Do.
,, 14th .	About 3 A.M., slight, about 6 secs. .	Mussoorie.
,, ,, .	3 A.M., slight	Naggar.
,, ,, .	7 A.M. all felt it	Do.
,, 15th .	9-15 P.M., not felt (Seis.) . . .	Simla.
,, 20th .	9-30 P.M., not felt (Seis.) . . .	Do.
,, 22nd .	Bed time, tremors	Naggar.
,, 26th .	1-54 A.M. Madras Time, not felt (Seis.)	Simla.
,, 27th .	About 6-15 P.M., smart . . .	Mussoorie.
,, ,, .	6-17 P.M., smart Town Hall rocked endwise, long slow motion.	Simla (felt also at Mussoorie).

Date.	Time and details of shocks.	Place.
1905, June 27th .	6-17 P.M., very smart (Seis.), felt generally.	Simla.
,, ,, .	6-28 P.M., sudden, 2 secs., slight .	Dehra Dun.
,, ,, .	9-53 P.M., not felt (Seis.) . .	Simla.
,, ,, .	18-0 G.M.T. (Seis. Omori) . .	Do.
,, ,, .	3-50 A.M., feeble	Mussoorie.
,, 28th .	7-42 A.M., felt (Seis.) . . .	Simla.
,, 29th .	5-56 A.M., not felt (Seis.). . .	Do.
,, ,, .	3-4 P.M., felt (Seis.) . . .	Do.
,, ,, .	3-12 P.M. (Seis. Omori) . . .	Do.
,, 30th .	10 P.M., sharp	Naggar.
1905, July 2nd* . .	9-07 A.M., 1 severe shock, W.—E. 30 seconds.	Dras.
,, ,, .	9-8 A.M., 2 shocks W.—E., lasting 2 secs.	Skardu.
,, 3rd .	7-22 P.M., 2 light shocks from W., 15 secs.	Dras.
,, ,, .	8-55 P.M. Standard time, not felt (Seis.)	Simla.
,, ,, .	9 P.M. Standard time (Seis. Omori) .	Do.
,, 4th .	2-3 A.M., not felt (Seis.) . . .	Do.
,, ,, .	4-15 P.M., not felt (Seis.) . . .	Do.
,, 6th .	5-45 A.M., not felt (Seis.) . . .	Do.
,, ,, .	16-20 (Seis. Omori) . . .	Do.
,, ,, .	17-50, not felt (Seis.) . . .	Do.
,, 7th .	4-15 A.M., felt (Seis.) . . .	Do.
,, ,, .	(During, night), feeble . . .	Mussoorie,
,, 10th .	11-5 P.M., sharp	Naggar.
,, ,, .	23-11, not felt (Seis.) . . .	Simla.
,, 14th .	14-0, not felt (Seis.) . . .	Do.
,, ,, .	15-55 Standard time (Seis. Omori) .	Do.
,, ,, .	16-6, not felt (Seis.) . . .	Do.
,, 15th .	14-30, not felt (Seis.) . . .	Do.
,, 18th .	2-6 A.M., not felt (Seis.) . . .	Do.
,, ,, .	3-0 A.M. Standard time (Seis. Omori).	Do.
,, ,, .	15-15, not felt (Seis.) . . .	Do.
,, 21st .	7-58 A.M., not felt (Seis.) . .	Do.
,, 23rd .	9-5 A.M., not felt (Seis.) . . .	Do.
,, 25th .	3-40 A.M., sharp and severe, awoke people.	Naggar.
,, ,, .	4-30 A.M., 2 or 3 secs., rather severe .	Dharmsala.
,, ,, .	18-50, felt (Seis.)	Simla.
,, 26th .	2-30 A.M., smart	Dharmsala Cantt.
,, ,, .	3-25 (local mean time), smart . .	Dehra Dun.
,, ,, .	3-43 A.M., to and fro. smart wavy	Do.
,, ,, .	motion. (Severest since 4th April 1905).	
,, ,, .	3-43 A.M., (6 secs.) roused the station	Mussoorie.

*From July onwards the times given in the Seismograph record are "Standard time" which is 6h. 30m. E. of Greenwich and from that date became railway time in India.

Date.	Time and details of shocks.	Place.
1905, July 26th .	3-45 A.M., smart	Dehra Dun.
,, ,, .	3-45 A.M., sharp several seconds, many people rushed out of houses.	Simla.
,, ,, .	3-45 A.M. (Seis. Omori, max. ampl. 1·75 mm.) *N. B.*—Not recorded on Milne Seismograph at Calcutta.	Do.
,, ,, .	3-50 A.M., severe, disturbed many people. Rumbling noise from N.—E., shook walls, roof and bed.	Ferozepur.
,, ,, .	3-50 A.M., very severe, (Seis.) 30 secs., felt by all.	Simla.
,, ,, .	4-30 A.M., smart	Dharmsala Cantt.
,, ,, .	(During night), smart . . .	Mussoorie.
,, 28th .	2 A.M., felt (Seis.)	Simla.
,, ,, .	2 25 A.M.	Dharmsala.
,, ,, .	4-30 A.M.	Do.
,, ,, .	8-10 A.M. (Seis. Omori . . .	Simla.
,, ,, .	8-25 A.M.	Dharmsala.
,, ,, .	10-10 P.M., an upward push . .	Naggar.
,, ,, .	11-35 P.M., distinct tremors, slight noise.	Do.
,, ,, .	6-5 A.M., not felt (Seis.) . . .	Simla.
,, ,, .	9-20 A.M., not felt (Seis.) . . .	Do.
,, ,, .	9-25 A.M.	Dharmsala.
,, ,, .	9-30 A.M., slight	Dharmsala Cantt.
1905, August 1st .	6-15 A.M., (about) feeble . . .	Rurki.
,, 3rd .	2-57 A.M., not felt (Seis.) . . .	Simla.
,, ,, .	20-40 (Seis. Omori) . . .	Do.
,, ,, .	22-8 felt (Seis.)	Do.
,, ,, .	10 P.M., feeble	Mussoorie.
,, 4th .	10 P.M., feeble	Holta, Palampur.
,, ,, . and 5th.	10-6 A.M. (Seis.)	Simla.
1905, August 6th.	13-57, not felt (Seis.) . . .	Do.
,, ,, .	4 P.M., slight	Naggar.
,, 8th .	6 A.M., smart	Do.
,, ,, .	15-0, not felt (Seis.) . . .	Simla.
,, 9th .	9 A.M., feeble	Naggar.
,, ,, .	20-25, not felt (Seis.) . . .	Simla.
,, 10th . September 15th.	No record. (Seismograph under repair).	Do.
1905, August 11th.	5 A.M., slight	Bajaura.
,, ,, .	3-15 P.M., smart	Dharmsala Cantt.
,, 12th .	3-40 A.M., feeble	Chakrata.
,, ,, .	10 P.M. (about), severe W.—E. first of any importance since 4th April 1905.	Murree.

Date.	Time and details of shocks.	Place.
1905, August 12th	10-9 P.M., smart S.—W., somewhat heavy, 3½ secs., accompanied by grating sound, no damage.	Ghoragali (Murree).
" "	10-10 P.M.	Khanspur near Dungagali, also Murree and Rawal Pindi. The last place gives 10-20 as the time.
" " .	10-14 P.M. (Seis. Omori) . .	Simla.
" " .	10-20 P.M., sharp, 6 secs. . .	Dungagali.
" " .	10-30 P.M., smart	Naggar.
" 13th .	6-15 A.M., slight	Bajaura.
" 15th .	2 A.M., slight	Naggar.
" " .	2-45 A.M., feeble	Holta, Palampur.
" " .	7-53 A.M. (Seis. Omori) . . .	Simla.
" " .	7-55 A.M., slight	Do.
" " .	8 A.M.	Do.
" " .	1-10 P.M., slight	Bajaura.
" " .	1-30 P.M., feeble	Naggar.
" " .	18-57 (Seis. Omori) . . .	Simla.
" " .	10 P.M., smart	Naggar.
" 16th .	5-45 P.M., slight	Dharmsala Cantt.
" 17th .	5-30 A.M., feeble	Holta (Kangra Valley).
" " .	4-30 P.M., slight	Naggar.
" 18th .	1 A.M., slight	Do.
" " .	5-45 P.M., slight	Dharmsala Cantt.
" 19th .	5 A.M., feeble	Naggar.
" " .	9 P.M., slight	Dharmsala Cantt.
" " .	9 P.M., smart	Holta, Palampur.
" 20th .	10 P.M., slight	Naggar.
" 21st .	4-17 A.M., slight	Bajaura.
" " .	4-30 A.M., smart	Naggar.
" " .	11-1 A.M. (Seis. Omori) . . .	Simla.
" " .	1 P.M., feeble	Naggar.
" " .	1-30 P.M., slight	Dharmsala Cantt.
" 22nd.	4-40 A.M., feeble	Chakrata.
" " .	8 A.M., feeble	Naggar.
" " .	4-30 P.M., smart	Do.
" " .	4-50 P.M., sharp	Bajaura.
" " .	7-15 P.M., slight	Dharmsala Cantt.
" " .	7-20 P.M., smart	Holta.
" " .	11 P.M., feeble	Naggar.
" 23rd .	7-30 A.M., smart	Do.
" " .	9 P.M., slight	Do.
" " .	11-55 P.M., short and extensive .	Bajaura.
" 24th .	5 A.M., sharp, awoke men from sleep .	Do.
" " .	6-0 P.M., slight	Naggar.
" " .	6-30 P.M., slight	Do.

Date.	Time and details of shocks.	Place.
1905, August 25th	9-0 A.M., feeble	Naggar.
" "	11-13 P.M. Tele. time, 2 severe shocks at intervals of 5 secs. N.—S. direction 25 secs. 2nd more severe than first, sound like thunder.	Deesa (N. Gujrat).
" 26th	11-30 P.M., slight	Naggar.
" 27th	8-30 A.M., fee le	Do.
" "	6 P.M., smart	Do.
" 28th	10-0 P.M., slight	Do.
" 29th	15-5 (Seis. Omori)	Simla.
" "	3-45 P.M., sharp shock, rumbling sound from S.	Bajaura.
" 30th	8-30 A.M., feeble	Naggar.
1905 Sept. 1st .	3 P.M., slight	Bajaura.
" " .	3-30 P.M., slight	Dharmsala Cantt.
" " .	10-30 P.M., (about) feeble, direction W.—E.	Rurki.
" 2nd .	6 A.M., smart	Naggar.
" " .	14-45, (Seis. Omori)	Simla.
" " .	4 P.M., feeble	Naggar.
" 4th .	5-50 P.M., sharp and noisy . .	Bajaura.
" 5th .	15-41 (Seis. Omori)	Simla.
" 6th[1] .	3-27 P.M. standard time, slight, 5 secs., house shook.	Jaipur (Rajputana).
" 7th .	3-55 A.M. slight, 5 or 6 people rushed out at night.	Mussoorie.
" " .	4 A.M., slight	Do.
" " .	About 4 [A.M.], feeble	Chakrata.
" 8th .	10 A.M., feeble	Naggar.
" " .	11 P.M., slight	Do.
" 9th .	1 P.M., slight	Do.
" 10th .	9 P.M., smart	Do.
" 11th .	2 A.M., slight . .	Dharmsala Cantt.
" " .	11 A.M., very severe, house shook and all went out.	Bajaura.
" " .	12-44 P.M. (Seis. Omori)	Simla.
" 13th .	5 A.M., slight	Naggar.
" 14th .	1 P.M., slight from S. . . .	Bajaura.
" " .	22-53 (Seis. Omori)	Simla.
" 15th .	8 A.M., feeble	Naggar.
" " .	9-40 A.M., severe	Bajaura.
" " .	11 P.M., smart	Naggar.
" 16th .	4 A.M., smart	Do.
" " .	(Early morning), slight . . .	Bajaura.
" " .	9 A.M., slight	Do.
" " .	(Afternoon) 4-30, slight . . .	Do.
" " .	6 P.M., feeble	Naggar.

[1] Separate earthquake, not aftershock, recorded by F. E. Place, B. Sc.

Date.		Time and details of shocks.	Place.
1905, Sept.	18th	4-15 P.M., slight with noise	Bajaura.
,,	19th	2 P.M., slight	Naggar.
,,	,,	5-30 P.M., slight	Dharamsala Cantt.
,,	,,	11 P.M., slight	Naggar.
,,	20th	11-33 A.M., feeble	Rurki.
,,	,,	9-50 P.M., long tremor	Mussoorie.
,,	,,	10 P.M., feeble	Do.
,,	,,	(No time given) resembling hard push from N.—S.	Bajaura.
,,	21st	4 A.M., smart	Naggar.
,,	,,	3-45 P.M., slight	Dharmsala Cantt.
,,	,,	8-15 P.M. slight	Ditto.
,,	22nd	5 A.M., smart	Naggar.
,,	,,	2 A.M., smart	Do.
,,	23rd	10-40 P.M., longish sound	Bajaura.
,,	24th	12-15 P.M., slight	Dharmsala Cantt.
,,	,,	8 P.M., severe with noise	Bajaura.
,,	25th	2-30 A.M., smart	Dharmsala Cantt.
,,	26th	4 P.M., longish and noisy	Bajaura.
,,	,,	1 A.M., slight	Do.
,,	,,	5-30 A.M., slight	Do.
,,	,,	6-55 A.M., severe, rest-houses at Rankan and Khan Mahomedkot damaged.[1]	Barkhan, Loralai.
,,	,,	7-55 A.M., severe	Ditto.
,,	,,	7 A.M., Ry. time E.—W. 30 secs.[2]	Multan Cantt.
,,	,,	7-2 A.M., felt (Seis.)	Simla.
,,	27th	7-58 A.M., not felt (Seis.)	Do.
,,	28th	5 A.M., feeble	Naggar.
,,	,,	9 P.M., slight	Do.
,,	29th	11 P.M., feeble	Holta.
,,	,,	6 A.M., feeble	Naggar.
,,	,,	11-20 A.M., feeble	Holta.
,,	,,	9 P.M., smart	Naggar.
,,	30th	7 A.M., smart	Do.
,,	,,	8 P.M., slight	Do.
1905, Oct.	1st	2-10 A.M., not felt (Seis.)	Simla.
,,	,,	8 A.M., feeble	Naggar.
,,	,,	9 P.M., slight	Do.
,,	2nd	10 A.M., slight	Do.
,,	,,	9 P.M., strong shock with great noise	Bajaura.
,,	3rd	5 A.M., slight	Naggar.
,,	,,	8 P.M., smart	Do.
,,	6th	11 A.M., slight	Do.

[1] Local earthquake. Information supplied by Political Agent, Loralai.
[2] Same earthquake. Information supplied by Executive Engineer, Dera Ghazi Khan.

Date.		Time and details of shocks.	Place.
905, Oct.	7th	20-18, not felt (Seis.)	Simla.
,,	,,	20-29, (Seis. Omori.)	Do.
,,	,,	8 P.M., severe or smart with rumbling	Bajaura.
,,	,,	8 P.M., smart	Naggar.
,,	8th	2 P.M., slight	Do.
,,	9th	2 A.M., smart	Do.
,,	10th	3 A.M., smart	Do.
,,	,,	1 8-03, not felt (Seis.)	Simla.
,,	,,	7 P.M., slight	Naggar.
,,	11th	12 P.M., slight	Do.
,,	14th	2 A.M., smart	Do.
,,	,,	5-40 A.M., slight	Bajaura.
,,	,,	5-55 A.M., not felt (Seis.)	Simla.
,,	,,	6-13 A.M., (Seis. Omori)	Do.
,,	15th	5 A.M., smart	Naggar.
,,	,,	11 A.M., sharp	Bajaura.
,,	,,	1 P.M., slight	Naggar.
,,	,,	3 P.M., sharp	Bajaura.
,,	,,	7-10 P.M., feeble	Holta.
,,	16th	About 3-4 A.M., feeble	Mussoorie.
,,	,,	9 A.M., slight	Naggar.
,,	,,	5 P.M., slight	Do.
,,	,,	10 P.M., smart	Do.
,,	17th	7 A.M., smart	Do.
,,	,,	9 A.M., smart	Do.
,,	,,	3 P.M., slight	Do.
,,	,,	10-45 P.M., feeble	Mussoorie.
,,	,,	22-40. (Seis. Omori.)	Simla.
,,	,,	22-52, felt distinctly as 2 shocks in rapid succession (Seis.)	Do.
,,	,,	11 P.M., smart	Naggar.
,,	18th	2-5 A.M., smart	Holta.
,,	,,	3 P.M., smart	Naggar.
,,	,,	14-12, not felt (Seis.)	Simla.
,,	,,	5 P.M., slight	Naggar.
,,	19th	0-44 A.M., not felt (Seis.)	Simla.
,,	,,	8 A.M., slight	Naggar.
,,	,,	9 P.M., smart	Do.
,,	20th	11-5, not felt (Seis.)	Simla.
,,	,,	2-30 P.M., slight	Naggar.
,,	,,	About 6-30 P.M.	Mussoorie.
,,	,,	19-30 (Seis. Omori).	Simla.
,,	,,	19-37, felt distinctly as 2 distinct shocks (Seis.)	Do.
,,	,,	8 P.M., smart	Naggar.
,,	21st	10-51 P.M., feeble	Holta.
,,	22nd	9-20 P.M., feeble	Do.
,,	23rd	4 P.M., slight	Naggar.

Date.			Time and details of shocks.	Place.
1905,	Oct.	23rd	16-20 (Seis. Omori)	Simla.
,,	,,	,,	16-20, not felt (Seis.)	Do.
,,	,,	24th	9-45 A.M., not felt (Seis.)	Do.
,,	,,	,,	3 P.M., smart	Naggar.
,,	,,	25th	1-19 A.M. (Seis. Omori)	Simla.
,,	,,	,,	8-36 A.M., not felt (Seis.)	Do.
,,	,,	,,	1-23, felt (Seis.)	Do.
,,	,,	,,	1-30 P.M., slight	Naggar.
,,	,,	,,	1-30 P.M., slight	Do.
,,	,,	,,	5 P.M., smart	Do.
,,	,,	26th	1 A.M., smart	Do.
,,	,,	,,	4 A.M., slight	Do.
,,	,,	27th	2-5 A.M., not felt (Seis.)	Simla.
,,	,,	,,	6 A.M., slight	Naggar.
,,	,,	,,	11 A.M., slight	Do.
,,	,,	,,	14-8, not felt (Seis.)	Simla.
,,	,,	,,	18-12, not felt (Seis.)	Do.
,,	,,	29th	4 A.M., slight	Naggar.
,,	,,	30th	11-10 A.M., feeble	Mussoorie.
,,	,,	,,	11-11 A.M. (Seis. Omori.)	Simla.
,,	,,	,,	11-12, not felt (Seis.)	Do.
,,	,,	1st	8 A.M., slight	Naggar.
,,	,,	,,	11-35 A.M., smart	Holta.
1905,	Nov.	1st	2-45 P.M., feeble	Do.
,,	,,	,,	10 P.M., slight	Naggar.
,,	,,	2nd	11-54 P.M., slight but long	Dehra Dun.
,,	,,	3rd	0-20, slight but long	Do.
,,	,,	,,	7-15 P.M., slight	Bajaura.
,,	,,	3-4th	Midnight., feeble	Dehra Dun.
,,	,,	4th	7-50 P.M., slight	Bajaura.
,,	,,	8th	1 P.M., slight	Naggar.
,,	,,	9th	8-20 P.M., tremor and noise	Bajaura.
,,	,,	12th	6-29 A.M., (Seis. Omori.)	Simla.
,,	,,	14th	8 A.M., slight	Naggar.
,,	,,	15th	6 A.M., feeble 2 secs.	Dehra Dun Cantt.
,,	,,	,,	11-50 A.M., feeble	Rurki.
,,	,,	,,	17-24 (Seis Omori.)	Simla.
,,	,,	,,	16-24 (4-24 P.M.)	Dehra Dun Cantt.
,,	,,	,,	4-23 P.M., feeble	Do.
,,	,,	,,	4-30 P.M. slight, furniture creaked, etc.	Do.
,,	,,	16th	2-30 A.M., smart	Holta.
,,	,,	17th	10 P.M., sharp	Bajaura.
,,	,,	18th	3 A.M., slight	Naggar.
,,	,,	,,	10-15 P.M., sharp	Bajaura.
,,	,,	,,	11 P.M., smart	Naggar.
,,	,,	22nd	11-30 P.M., smart	Do.
,,	,,	23rd	3-15 A.M. (Seis. Omori.)	Simla.

Date.	Time and details of shocks.	Place.
1905, Nov. 23rd .	2 or 3 hours before sunrise, feeble .	Dehra Dun.
„ „ .	3-35 A.M., sharp strong and longish from N.; all ran out of house.	Bajaura.
„ „ .	3-55 A.M., feeble	Rurki (also Simla).
„ 24th .	2 A.M., smart . . .	Naggar.
„ „ .	8 A.M. (Seis. Omori.) . . .	Simla.
„ „ .	7 P.M., slight	Naggar.
„ 28th .	5-15 A.M., smart, ...	Holta.
„ „ .	10-20 A.M., slight with noise . .	Bajaura.
1905, Dec. 1st .	9.45 P.M., loud noise like thunder .	Do.
„ 4th .	8 P.M., rumbling noise from N. . .	Do.
„ 5th .	11-35 P.M., sharp preceded by rumbling noise from N. N. E.	Do.
„ 7th .	9-15 A.M., feeble	Holta.
„ 10th .	3 A.M., sharp 6 secs. with upward push	Bajaura.
„ 11th .	2-53 (Seis. Omori)	Simla.
„ 12th .	8-54 P.M., feeble felt by 2 people .	Rurki.
„ 13th .	5-25 P.M., severe prolonged shock 30 secs. with rolling noise . . .	Bajaura.
„ „ .	17-28 (Seis. Omori.)	Simla.
„ „ .	5-48 P.M., less severe	Bajaura.
„ „ .	18-7 (Seis. Omori.)	Simla.
„ 14th .	17-24 (Seis. Omori.)	Do.
„ 15th .	2-10 A.M., smart	Bajaura.
„ 17th .	6-13 A.M., smart	Holta.
„ „ .	11-41 A.M. (Seis. Omori.) . .	Simla.
„ „ .	11-50 A.M., smart	Holta.
„ 18th .	3 P.M., slight	Bajaura.
„ 19th .	10-15 P.M., upward push and booming noise.	Do.
„ 21st .	7-15 P.M., upward push and noise .	Do.
„ 22nd .	5-20 A.M., slight with noise . .	Do.
„ „ .	17-20 (Seis. Omori)	Simla.
„ 23rd .	3-15 P.M., a quiver	Bajaura.
„ 24th .	12-15 P.M., feeble	Rurki.
„ 25th .	2-45 A.M., very sharp	Bajaura, also felt at Belaspore and at Seroho and Abu Road, Rajputana.
„ 26th .	2-34 (Seis. Omori)	Simla.
„ 28th .	All day at intervals of 1 hour . .	Bajaura.
„ 29th .	About 4-30 P.M., feeble	Balolpur Camp, Sirhind.
„ 29th .	7-30 P.M., feeble	Holta.
1906, Jan. 3rd .	21-14, severe shock	Bajaura.
„ 6th .	6-55 P.M., smart	Holta.
„ 7th .	23-19, severe	Bajaura.
„ 8th .	8-40 A.M., smart	Holta.

Date.	Time and details of shocks.	Place.
1906, Jan. 9th .	9-15 A.M., slight	Bajaura.
" 11th .	16-13, slight	Do.
" 14th .	20-10, slight	Do.
" 16th .	10-12 A.M., slight	Do.
" " .	17-20, slight	Do.
" 17th .	20-31, severe	Do.
" 21st .	14-12, slight	Do.
" 24th .	8-40 P.M., sharp preceded by prolonged rumble, many people rushed out of houses.	Lahore.
" 25th .	9-47 (Seis Omori)	Simla.
" 29th .	3-30 P.M., sharp	Shahpur (Kangra).
" " .	15-47 (Seis. Omori)	Simla.
" " .	3-45 P.M., smart	Holta.
" " .	15-37 (Seis.)	Simla, Kelvin Grove.*
" 31st .	6-10 A.M., feeble	Holta.
1906, Feb. 2nd .	7-26 (Seis. Omori.)	Simla.
" " .	7-30 (Seis.) Kelvin Grove . . .	Do.
" " .	15-3 (Seis. Omori.)	Do.
" " .	15-30 (Seis.) Kelvin Grove . .	Do.
" " .	16-58 (Seis. Omori.)	Do.
" " .	16-55 (Seis.) Kelvin Grove . .	Do.
" " .	20-20 (Seis.) Kelvin Grove . .	Do.
" 9th .	7-10 A.M., severe	Bajaura.
" 10th .	2-20 A.M. (Seis.) Kelvin Grove . .	Simla.
" " .	14-29, slight	Bajaura.
" " .	18-7, slight	Do.
" 12th .	13-15 ? (Seis.) Kelvin Grove . .	Simla.
" 13th .	19-3, slight, ...	Bajaura.
" 14th .	12-15 P.M. (Seis. Omori) . . .	Simla.
" " .	12-15 A.M. (Seis.) Kelvin Grove .	Do.
" 15th .	(Night), feeble	Rurki.
" 16th .	23-35, severe	Bajaura.
" " .	16-0 (Seis.) Kelvin Grove . .	Simla.
" 17th .	20-8 (Seis. Omori)	Do.
" " .	8-15 P.M., slight, E.—W. . .	Mussoorie.
" 18th .	19-30 (Seis. Omori)	Simla.
" " .	19-35 (Seis.) Kelvin Grove . .	Do.
" 23rd .	21-0 (Seis.) Kelvin Grove . .	Do.
" 25th .	12-45 (Seis.) Kelvin Grove . .	Do.
" 27th .	4-10 P.M., slight tremors 3 secs. .	Jaipur.
" " .	7-15 P.M.	Larji, Kulu.
" 28th .	1-12 (?) A.M., beginning of large waves (Seis. Omori) Amplitude 4 mm., duration 2·5 minutes.	Simla.

* Recorded by Mrs. W. Henry on the Agamennone Seismoscope.

Date.	Time and details of shocks.	Place.
1906, Feb. 28th .	1-15 A.M. (Seis). Kelvin Grove, cracked a few buildings and is reported from many places in Punjab.	Simla.

Note: —The records which follow at the various times indicated on the 28th obviously refer mostly to the single big after-shock as timed above. The varied times are therefore due to inaccurate estimates, and the shocks must not be considered as separate subsequent shocks, the more correct list of which is given later derived from the seismographs at Simla.

1906, Feb. 28th .	Midnight, slight	Ladak (Leh).
	About 12 o'clock. From Palampur direction. Next in severity to that of 4th April 1905. Some houses have partially suffered, people greatly frightened.	Hamirpur (Kangra District).
,, ,, .	12-30 A.M. From E. In Kothi Hinuri, seven persons killed, 8 wounded and 5 cattle, 22 sheep, 1 goat killed. In Kothi Koh 1 person killed, 19 cattle 22 sheep and goats killed, 111 houses demolished. In Kothi Srigarh 3 persons wounded. In Kothi Kandi 1 person killed, 19 houses demolished. In Kothi Tung 9 persons killed, 11 wounded, 124 cattle and 22 sheep killed.	Saraj Tehsil.
,, ,, .	The District Board road from Chunagali to Kundagah badly damaged in several places. The Tahsil school and other District Board buildings badly damaged, but can be repaired.	
,, ,, .	0-35 A.M., very severe, 2 people killed, 21 injured in Rampur town. Court-house and buildings damaged. Post Office and police station collapsed. At Kakoota, 5 miles S. of Rampur, dwellings were destroyed, 6 men killed and 2 injured.	Bashahr (Simla Hill States).
,, ,, .	0-45 A.M., very severe, the worst since 4th April 1905; lasted 50 seconds.	Bajaura.
,, ,, .	1 A.M., slight, N.—S., duration about 1 min.	Sirsa.
,, ,, .	1 A.M. (approximately), from S. E. No loss.	Dehra Gopipur (Kangra dist.).

Date.	Time and details of shocks.	Place.
1906, Feb. 28th .	About 1 A.M., strong 1 prolonged shock. Duration 1 min.	All Kulu from Sutlej to Manali, also at Leh.
" " .	1-0(?), very slight; no damage.	Cherat.
" " .	1-0 (?), severe N.—S., no damage.	Amballa.
" " .	After 1-0 A.M., slight W.—E.	Dehra Ismail Khan.
" " .	After 1-0 A.M., 8 secs, duration. E.—W. with gentle rocking. No damage.	Murree.
" " .	After 1 A.M., from E., some buildings have cracked. No serious loss.	Kangra.
" " .	Between 1 and 1-30 A.M., distinct tremor.	Montgomery.
" " .	1-5 A.M., sharp, duration 5-6 seconds.	Rohtak.
" " .	1-8 A.M., smart, N.—S., noticed by all, 20—30 seconds duration; 3 distinct movements.	Mussoorie.
" " .	1-10 A.M., severe. All rushed out of houses. Panic and great noise in the city.	Amballa.
" " .	1-10 A.M. Decided shock. Heavy rumblings, W.—E.	Agra.
" " .	1-10 A.M., smart distinct oscillation. Roof creaked.	Jawalapur (about 20 miles E. of Rurki).
" " .	1-12 A.M., duration 6-7 seconds, S.—N. not very severe.	Lahore.
" " .	1-14 A.M., severe shock, direction N.—S.	Chakrata.
" " .	1-14 A.M. 2 sharp shocks. Few seconds duration. No damage.	Dehra Dun.
" " .	1-14 A.M., severe. Direction N.—S. Damage slight.	Simla.
" " .	1-15 A.M., smart. Nearly everyone awakened. Many left beds or houses. Rumbling noise. Punkah frame swung fully 15 inches.	Rurki.
" " .	1-15 A.M., 8 seconds duration . .	Sialkot.
" " .	1-15 A.M., N. W.—S. E. No loss. Cracks in 2 or 3 buildings.	Palampur.
" " .	1-17 A.M., smart	Saharanpur.
" " .	1-18 A.M., slight. A quite noticeable tremor. Small articles shook. Duration 10 seconds.	Jaipur.
" " .	1-19 A.M., fairly severe with slight noise. N.—S. 4 or 5 oscillations. Duration 1 min. Wall of Hindu temple cracked.	Ludhiana.

Date.	Time and details of shocks.	Place.
1906, Feb. 28th .	1-20 A.M., severe. W.—E. No damage	Meerut.
„ „ .	1-22 or 23 A.M., very smart. Woke all people up. They left houses. Magnetic records show that the shock was preceded by a magnetic disturbance.	Dehra Dun.
„ „ .	1-25 A.M., duration 5 seconds, S. W.—N. E. A.M., damage not great.	Shahdara (Kangra District.).
„ „ .	1-28 mild with tremor 10 mins. after.	Delhi.
„ „ .	1-30 A.M., duration a few seconds. No damage.	Srinagar.
„ „ .	1-30 A.M., from N.E. No loss .	Nurpur (Kangra Dist.)
„ „ .	Here follow seismographic records from Simla for aftershocks of the above occurring on the 28th. All are grouped together for convenience.	
„ „ .	1-25 (?) A.M. (Seis. Omori) .	Simla.
„ „ .	1-25 A.M. (Seis.) Kelvin Grove .	Do.
„ „ .	1-34 (?) A.M. (Seis. Omori) . .	Do.
„ „ .	1-25 A.M. (Seis.) Kelvin Grove .	Do.
„ „ .	1-36 (?) A.M. (Seis. Omori) . .	Do.
„ „ .	1-37 A.M. (Seis.) Kelvin Grove .	Do.
„ „ .	1-45 A.M. (Seis.) Kelvin Grove . .	Do.
„ „ .	1-46 A.M. (Seis. Omori) . . .	Do.
„ „ .	2-20 A.M. (Seis.) Kelvin Grove . .	Do.
„ „ .	2-27 (?) A.M. (Seis. Omori) . .	Do.
„ „ .	2-45 A.M. (Seis.) Kelvin Grove . .	Do.
„ „ .	3-20 (?) A.M. (Seis. Omori) . .	Do.
„ „ .	3-20 A.M. (Seis.) Kelvin Grove[1] .	Do.
„ „ .	10-42 (?) A.M. (Seis. Omori) . .	Do.
„ „ .	21-37 (?) (Seis. Omori) . . .	Do.
„ „ .	2-20 A.M., 3 slight shocks, duration 6—7 seconds. N.—S.	Bareilly.
„ „ .	About 4 A.M. feeble . . .	Kalsi (W. Dun).
„ „ .	4 A.M. small	Agra.
„ „ .	5 A.M. [probably an error] W.—E. sharp. Lasted 5 seconds ; most severe since 4th April 1905.	Dehra Dun.
1906, March 1st .	(2 shocks per hour) . . .	Banjar, Kulu.
„ „ .	6-20 (?) A.M. (Seis. Omori) . .	Simla.
„ „ .	10-53 (?) A.M. (Seis. Omori) . .	Do.
„ „ .	14-16 (Seis. Omori) . . .	Do.
„ „ .	15-13 (Seis. Omori) . . .	Do
„ 2nd .	(About 1 shock per hour) . .	Banjar Kulu.
„ „ .	11-55 A.M. (Seis. Omori) . . .	Simla.

[1] After this date the instrument at Kelvin Grove was out of working order.

Date.	Time and details of shocks.	Place.
1906, Mar. 3rd .	(Shocks continuing)	Banjar, Kulu.
" 7th .	23-24 (Seis. Omori) . . .	Simla.
" 8th .	8-35 A.M., felt	Do.
" " .	9-37 A.M. (Seis. Omori) . . .	Do.
" " .	21-18 (?) (Seis. Omori) . . .	Do.
" 9th .	16-33 (Seis. Omori) . . .	Do.
" 10th .	15-14 (Seis. Omori) . . .	Do.
" 11th .	1-15 A.M. very severe . . .	Bajaura.
" 12th .	5 A.M., felt	Simla.
" " .	9-30 A.M., slight	Bajaura.
" " .	14-15 (Seis. Omori) . . .	Simla.
" 13th .	2-48 A.M. (Seis. Omori) . . .	Do.
" " .	17-53 (Seis. Omori) . . .	Do.
" 14th .	10 28 A.M. (Seis. Omori). . .	Do.
" " .	14-59 A.M. (Seis. Omori) . . .	Do.
" 15th .	8-21 A.M. (Seis. Omori) . . .	Do.
" 17th .	1-35 A.M. (Seis. Omori) . . .	Do.
" 18th .	18-30 (Seis. Omori) . . .	Do.
" 19th .	5-35 A.M., slight	Bajaura.
" " .	11-15 A.M., slight	Do.
" 20th .	3-35 A.M., slight	Do.
" " .	6-20 A.M., slight	Do.
" " .	10-42 A.M., (Seis. Omori) . .	Simla.
" " .	10-45 A.M., felt	Do.
" 22nd.	12-10, tremor and noise . . .	Bajaura.
" 26th .	3-20 A.M., to 5-30 A.M., } Strong shocks of about 7 seconds.	Do.
" " .	9-20 A.M., } Felt in Bombay too.	
" " .	21-2 P.M., felt	Simla.
" 27th .	2-30 A.M., } Sharp quick shocks seconds.	Bajaura.
" " .	7-20 A.M., }	
" 29th .	6. A.M., } Rumbling noise .	Do.
" " .	7-50 A.M., }	
" " .	6-52 A.M., felt	Simla.
" " .	7-25 A.M., felt	Do.
" 31st .	4-30 A.M. } Sharp short shocks .	Ba au a.
" " .	9- P.M. }	
1906, April 1st .	12-55 A.M., noise and shock[1] . .	Do.
" 2nd .	7-20 A.M., slight	Do.
" 6th .	Sharp	Do.
" " .	Slight	Do.
" 7th .	12-10 A.M., sharp, made observer jump out of bed.	Do.
" 8th .	16-43 (Seis. Omori). . . .	Simla.

[1] Col. Rennick describes all these noises and shocks of this month as being nearly instantaneous like the passing of an express train. All seemed to travel N. N. E.—S. S. W.

Date.	Time and details of shocks	Place.
1906, April 9th .	14-10 (Seis. Omori). . . .	Simla.
" 10th .	16-35, felt also (Seis. Omori) . .	Do.
" 15th .	4-5 A.M., a noisy shore . . .	Bajaura.
" " .	1-53 P.M., a sharp shock noticed all over the place.	Do.
" 17th .	6-45 A.M., felt	Simla.
" " .	12-0 A.M. [(?)midday], noise and shore up.	Bajaura.
" 21st .	4-A.M., noise and shore up . .	Do.
" 23rd .	2-53 A.M., sharp " woke me" . .	Do.
" 25th .	9-P.M., sharp, noticed by all . .	Do
" 28th .	3 P.M., a smart shock with noise, noticed also in Sultanpur.	Do.
" 30th .	——— - - slight, no noise . .	Do.
" " .	2-30 P.M., a very sharp shock, duration 5—6 secs., servants began to run.	Do.
" " .	2-40 P.M., slight	Do.
" " .	2-40 P.M., felt	Simla.
" " .	14-41 (Seis. Omori). . . .	Do.
" " .	4-20 P.M., great rumbling without shock.	Bajaura.
" " .	21-0, distinctly felt ; sitting . .	Simla.
1906, May 4th .	3-50 A.M.[1] Severe, most residents aroused from sleep. Duration 4 secs.	Darjeeling.
" " .	10-30 P.M. Slight with upward push .	Bajaura.
" 7th .	7-47 A.M. (Seis. Omori) . . .	Simla.
" 10th .	2-A.M. Sharp, " awoke us from sleep"	Bajaura.
" " .	2-P.M.	Do
" 11th .	0-15 A.M.	Do.
" " .	1-18 A.M. (Seis. Omori) . . .	Simla.
" 12th .	Generally noticed . . .	Darjeeling.
" " .	11-22 A.M. (Seis. Omori) Estimated distance 852 miles.	Simla.
" 16th .	1-49 A.M. to 2-6 A.M. (Seis. Omori .	Do.
" 17th .	11-23 A. M. (Seis. Omori) . .	Do.
" 18th .	17-8 to 17-13 (Seis. Omori) . .	Do.
" 19th .	2-40 A.M. to 2-41 (Seis. Omori) .	Do.
" 20th .	4-30 P.M. Smart, doors and windows rattled, lamps swung E.—W. Duration 6 secs.	Mussoorie.
" " .	4-35 P.M. Smart. E.—W. Preceded by a rumbling. No damage. Followed by slighter shock 2 mins. after.	Delhi.

1 Probably local shock and not connected with the Kangra earthquake aftershocks.
2 Separate local shock, also recorded by the Alipur seismograph.

Date.	Time and details of shocks.	Place.
1906, May 20th .	4-40 P.M. Smart. E.—W. Noticed by all. Doors and windows rattled. Duration 3—4 secs., 2 shocks with 1 min. interval.	Lynndale, Mussoorie.
,, ,, .	4-40 P.M. 2 shocks with 1 min. interval. Smart, 3 secs. duration each. Preceded by a rumbling.	Dehra Dun.
,, ,, .	16-42 to 17 (Seis. Omori) . .	Simla.
,, ,, .	4-43 P.M. Two bumps followed by a tremor and another shock at 4-46.	Jaipur, Rajputana.
,, ,, .	4-45 P.M. Slight	Lahore.
,, ,, .	4-45 P.M. Smart	Bijnor.
,, ,, .	4-45 P.M. Smart. W.—E. Doors rattled. Person seated felt sharp blow on chair legs (W. side) just before rattling began.	Rurki.
,, 24th .	19-38 (Seis. Omori)	Simla.
,, 26th .	3-30 A.M. A severe shock felt from Manali to Larji. All left their beds.	Bajaura.
,, 28th .	8-40 A.M. Sharp felt by all . .	Do.
,, ,, .	11 A.M.	Do.
,, ,, .	12 midnight	Do.
,, 31st .	3-30 A.M. Very sharp. Noticed by all.	Do.
1906, June 1st .	10-20 A.M. to 10-23 A.M. (Seis. Omori)	Simla.
,, 9th .	2-30 P.M. Great rumbling noise .	Bajaura and Naggar.
,, 11th .	20-10 (Seis. Omori)	Simla.
,, 12th .	17-36 (Seis. Omori)	Do.
,, 13th .	11-10 P.M. Severe. Every one ran out alarmed. Felt all through the Valley of Kulu.	Bajaura, Naggar, etc.
,, ,, .	23-15 (Seis. Omori) Also reported from Chakrata to Meerut.	Simla.
,, ,, .	11-15 P.M.[1] Smart N.-S. ? Noticed by a great number. House shock. Doors rattled.	Lynndale, Mussoorie.
,, ,, .	11-19 P.M. Sharp to severe oscillation, lasted 3—4 secs. The most severe since 28th February 1906. Imperial Secretariat Buildings on Gorton Hill slightly damaged. Also many natives spent the night in the open. Felt also at Mahasu and Mashobra.	Simla.
,, ,, .	11-20 P.M. Smart	Dehra Dun.
,, ,, .	11-35 P.M. Rather severe, lasted few seconds.	Saharanpur.

[1] Given as June 14th in Mr. Mackinnon's form, doubtless a slip.

Date.	Time and details of shocks.	Place.
1906, June 13th .	Midnight	Bajaura and Naggar.
" 14th .	2 A.M. Feeble	Dehra Dun.
" 15th .	2-30 A.M. Sharp, felt all through Kulu Valley.	Bajaura, Naggar, etc.
" 16th .	20-29 (Seis. Omori)	Simla.
" 18th .	13-30 to 13-31 (Seis. Omori) . .	Do.
" " .	1-30 P.M. Sharp, felt all through Kulu Valley.	Bajaura, Naggar, etc.
" 20th .	2-40 A.M. Sharp upward shock .	Bajaura and Naggar.
" " .	1 P.M. Sharp upward shock . .	Ditto.
" 21st .	6-45 P.M. Sharp. Duration 2 or 3 secs. All fled out of house.	Ditto
" " .	6-45 P.M. Slight	Lynndale, Mussoorie.
" " .	18-48 to 18-51 (Seis. Omori) . .	Simla.
" " .	6-50 P.M. Smart but very short. .	Dehra Dun.
" " .	7 P.M. Smart. Duration 2 or 3 secs. only.	Simla.
" " .	21-50 (Probably local) . . .	Mount Abu.
" " .	22-30 (Probably local) . . .	Ditto.
" 24th .	15-20 (Seis. Omori)	Simla.
" 26th .	4-15 A.M. Sharp shock coincident with cloud burst which did great damage.	Bajaura and Naggar.
1906, July 3rd .	10 P.M. Slight	Ditto.
"	22-28 (Seis. Omori)	Simla.
" 4th .	1-45 P.M. 1 shake	Bajaura and Naggar.
" 7th .	8-40 P.M. Slight	Ditto.
" 10th .	1-55 A.M. (Seis. Omori) . .	Simla.
" " .	10-30 A.M. Slight . . .	Bajaura and Naggar.
" 18th .	3-40 P.M. Slight	Ditto.
" 21st .	1-45 A.M. Very severe. Duration 5-10 secs. No damage.	Kangra.
" " .	1-50 A.M. Severe. "Sent us out of bed. Wired to Civil and Military Gazette."	Bajaura and Naggar.
" " .	1-50 A.M. Severe. People much scared.	Naggar.
" " .	1-55 A.M. Smart. Very short 4-5 secs.	Dehra Dun.
" " .	1-57 A.M. (Seis. Omori). Generally felt in Kashmir and reported from Rawalpindi and Lodhiana.	Simla.
" " .	2 A.M. Smart. Duration 5 secs. followed by slighter one hour after.	Mussoorie.
" " .	2 A.M. Slight. Duration 4-5 secs. .	Lahore.[1]

[1] This shock also reported from Delhi, Dalhousie and a wide area in western Himalayas. Several shocks were felt for nearly a minute in some places whilst tremors continued for 2—13 minutes.

Date.	Time and details of shocks.	Place.
1906, July 21st .	2h. 27′-30″ (local mean time which is 5h. 53′-27″ E. of Greenwich 2h. 3′-45″ standard time. Tremor felt and recorded by H. F. Magnetograph.	Barrackpore.
„ 26th .	7-70 (*Sic.*) (?) A.M. or P.M. Smart .	Bajaura and Naggar.
„ „ .	22-40 (Seis. Omori) . . .	Simla.
„ 29th .	0-33 A.M. (Seis. Omori) . . .	Do.
1906, Aug. 9th .	13-58 (Seis. Omori) . . .	Do.
„ 10th .	2-30 A.M.	Sonemarg and Dras.
„ 11th .	1-26 A.M. (Seis. Omori) . . .	Simla.
„ 15th .	16-55 (Seis. Omori) . . .	Do.
„ 16th .	3-45 A.M. Lasted for several seconds	Rajputana and Gujrat.
„ „ .	3-48 A.M.	Mount Abu.
„ „ .	3-56 A.M.	Do.
„ „ .	4-20 A.M.	Do.
„ 17th .	*Valparaiso Earthquake*	
„ 23rd .	11-42 A.M. Sharp	Bajaura.
„ 28th .	1-50 P.M. With a great rumbling noise	Do.
„ 31st .	11 P.M. Sharp	Do.
1906, Sep. 1st[1] .	12-40 P.M. Sharp	Do.
„ 10th .	1-15 A.M. Sharp	Do.
„ 15th .	21-51 to 21-53 (Seis. Omori) . .	Simla.
„ 16th .	9-53 P.M. Steady push . . .	Bajaura.
„ 19th .	14-52 (Seis. Omori). . . .	Simla.
„ 26th .	12-10 A.M. Sharp	Bajaura.
1906, Oct. 4th .	3 A.M. (about)	Darjeeling.[2]
„ 5th .	10-6 to 10-7 (Seis. Omori) . .	Simla.
„ 6th .	2-15 A.M. Sharp	Bajaura.
„ 11th .	2-5 A.M. Sharp	Do.
„ 12th .	1 P.M. One strong shake . .	Do.
„ 13th .	5-6 A.M. Sharp	Do.
„ 21st .	12-23 to 12-26 (Seis. Omori) . .	Simla.
„ 24th .	8-21 P.M. (Seis).	Do.
„ 26th .	10-9 A.M. Rumbling noise and sharp shock.	Bajaura.
27th .	9-44(?) A.M. Rumbling noise and sharp push upward.	Do.
„ 28th .	9-35 P.M. (Seis.)	Simla.
1906, Nov. 3rd .	11-45 P.M. (Seis.)	Do.
„ 5th .	8-40 to 8-45 (Seis. Omori) . .	Do.
„ 6th .	11-51. Lasting 25 secs. . . .	Mount Abu.
„ 8th .	16-26. Lasting 14 secs. . . .	Do.
„ 9th .	1-55 P.M. (Seis.) Felt by some .	Simla.

[1] All September in Kulu shocks came from N.E.—S. W.

[2] Probably a local shock.

Date.	Time and details of shocks.	Place.
1906, Nov. 11th .	10-15 P.M. Sharp push with rumbling noise from N.	Bajaura and Kulu Valley.
" 12th .	21-48 to 22-1 (Seis. Omori) . .	Simla.
" 13th .	10-10 P.M. Very sharp shock N.-S. Duration 5—8 secs. All servants ran out of their house, preceded by a great noise.	Bajaura and Kulu Valley.
" 19th .	10 A.M. (Seis.)	Simla.
" 20th .	3 A.M. Slight	Bajaura and Kulu Valley.
" " .	6-22 A.M. (Seis. Omori) . . .	Simla.
" " .	8-30 A.M. (Seis.) Felt by some . .	Do.
" " .	1-50 P.M. Very sharp shock stronger at Manali and Naggar than at Bajaura.	Bajaura and Kulu Valley.
" " .	13-54 (Seis. Omori).	Simla.
" " .	1-55 P.M. (Seis.)	Do.
" 21st .	12-36 to 12-38 (Seis. Omori) . .	Do.
" 22nd .	4-20 A.M. Sharp	Bajaura and Kulu Valley.
" " .	8-20 A.M. (Seis.)	Simla.
" 24th .	8 A.M. (Seis.)	Do.
" 25th .	5 A.M. (Seis.).	Do.
" " .	9 A.M. (Seis.).	Do.
" 27th .	11-17 (Seis. Omori).	Do.
1906, Dec. 1st .	7-2 A.M. (Seis.) Felt in bed . .	Do.
" 2nd .	9-20 A.M. (Seis.)	Do.
" 3rd .	8-20 A.M. (Seis.)	Do.
" 5th .	11-12 A.M. (Seis.)	Do.
" 6th .	17-39 (Seis. Omori).	Do.
" " .	17-45 (Seis. Omori).	Do.
" 7th .	5-20 A.M. Strong shock . . .	Bajaura and Kulu Valley.
" 10th .	0-37 to 0-38 (Seis. Omori) . .	Simla.
" 13th .	6-10 A.M. Slight . . .	Bajaura and Kulu Valley.
" " .	18-40 to 18-50 (Seis. Omori) . .	Simla.
" 14th .	7-7 P.M. Very slight tremor . .	Rurki.
" 18th .	5-8 A.M. (Seis.) Felt in bed . .	Simla.
" " .	9-40 A.M. (Seis.)	Do.
" 19th .	14-22 to 14-25 (Seis. Omori) . .	Do.
" 21st .	11-30 A.M. (Seis.) Felt sitting in verandah.	Do.
" 22nd .	8-30 A.M. (Seis.)	Do.
" 23rd .	12-10 A.M. (Seis.)	Do
" " .	2 long distance shocks	Do.
" 25th .	8-7 A.M. (Seis.)	Do.
" 29th .	3 P.M. (Seis.)	Do.

Date.	Time and details of shocks.	Place.
1906, Dec. 31st .	6 5 P.M. (Seis.)	Simla.
1907, Jan. 1st .	7-55 P.M. (Seis.)	Do.
" 4th .	Long distance shock . . .	Do.
" 10th .	19-35 to 19-36 (Seis. Omori) . .	Do.
" " .	8-0 P.M (Seis.) Smartly felt . .	Do.
" " .	8-7 P.M. Sharp	Bajaura and Kulu Valley.
" 11th .	12-15 A.M. (Seis.)	Simla.
" " .	22-3 (Seis. Omori)	Do.
" " .	10-10 P.M. (Seis.) Felt in bed . .	Do.
" 13th .	9-15 A.M. (Seis.)	Do.
" 16th .	10-5 P.M. (Seis.)	Do.
" 17th .	11-10 P.M. Slight with rumbling	Bajaura and Kulu Valley.
" 19th .	22-2 to 22-3 (Seis. Omori) . .	Simla.
" .	10-5 P.M. (Seis.) Distinctly felt .	Do.
" 23rd .	1-18 to 1-19 (Seis. Omori) . .	Do.
" " .	1-20 A.M. Smart. Two shocks with interval of a few seconds.	Mussoorie.
" 31st .	6-5 A.M. Sharp with rumbling .	Bajaura and Kulu Valley.
" " .	1-10 P.M. Sharp with rumbling .	Ditto.
1907, Feb. 1st .	7-55 A.M. Slight	Bajaura.
" 16th .	10-11 P.M. Slight shock. Club bar glasses rattled.	Delhi.
" 17th .	4 A.M. (about). Doors slammed, bed shook.	Do.
" 20th .	9-15 A.M. (Seis.)	Simla.
" 23rd .	15-30 (Seis. Omori)	Do.
" " .	4-10 P.M. Sharp	Bajaura and in Kulu Valley and Parba River to Manikarn.
" " .	4-23 P.M. (Seis.) Distinctly felt .	Simla.
1907, Mar. 2nd .	21-34 to 21-36 (Seis. Omori) . .	Do.
" 3rd .	9-20 P.M. Sharp from N. N. W. .	Bajaura.
" " .	9-30 P.M. (Seis.) Very smart shock .	Simla.
" 4th .	1-21 A.M. Sharp from N. N. W. .	Bajaura.
" 19th .	17-51 to 17-52 (Seis. Omori) . .	Simla.
" " .	5-55 P.M. (Seis.)	Do.
" " .	9-30 P.M. (Seis.) Very smart . .	Do.
" 20th .	Three sharp shocks during night .	Bajaura.
" " .	6-50 A.M. (Seis.) Felt by all . .	Simla.
" 21st .	5-14 A.M. Severe push upwards .	Bajaura.
" " .	5-45 A.M. (Seis.)	Simla.
" " .	5-45 A.M. (Seis. Omori)	Do.
" " .	3 P.M. (Seis.)	Do.
" " .	9-25 P.M. Very sharp shock from S. S. W.	Bajaura and Kulu Valley and Mandi.

Date.	Time and details of shocks.	Place.
1907, Mar. 22nd .	8-53 (?) to 8-60 (Seis. Omori) .	Simla.
" 23rd .	8-30 A.M. (Seis.)	Do.
" 25th .	7-50 A.M. (Seis.) Felt in bed . .	Do.
" 27th .	11-45 A.M. (Seis.)	Do.
" 28th .	11-45 P.M. Slight	Bajaura.
" 29th .	Long distance . . .	Simla.
" 30th .	2-25 A.M. (Seis) Felt in bed . .	Do.
" 31st .	11-25 to 11-31 (Seis. Omori) . .	Do.
1907, April 7th .	10-5 P.M. With rumbling noise .	Bajaura.
" 8th .	12-16 A.M. Sharp	Do.
" 10th .	8-39 A.M. (Seis. Omori) . . .	Simla.
" " .	8-45 A.M. (Seis.)	Do.
" 13th .	12-45 P.M. (Seis.)	Do.
" " .	15-44 (Seis. Omori)	Do.
" " .	3-43 P.M. (Seis.) felt distinctly . .	Do.
" " .	4-45 P.M. Severe shock followed by smaller ones.	Bajaura.
" " .	17-58 to 18-15 (Seis. Omori) . .	Simla.
" " .	11-37 P.M. (Seis.). Slight shock followed by a rumbling and prolonged gentle wave. Also felt in Peshawar and Lahore.	Do.
" 15th .	Long distance. *Mexico* (Seis. Omori)	Do.
" 17th .	Long distance. *Askabad* (Seis. Omori)	Do.
" 18th .	Long distance. *Spain* (Seis. Omori)	Do.
" 20th .	10-45 P.M. Two sharp shocks with noise	Bajaura.
" 22nd .	11-55 A.M. (Seis. Omori) . .	Simla.
" 27th .	7-10 A.M. Sharp	Baraura.
1907, May 9th .	2 P.M. Two Sharp shocks which made the poeple run out of the tahsil.	Bajaura and Kulu Valley.
" 15th .	1 P.M. A sharp downward fall. Felt also in Mandi.	Ditto.
" 18th .	8 A.M. (Seis.) Felt upstairs in bed distinctly.	Simla.
	8-7 A.M. (Seis. Omori)	Do.
" 24th .	21-58 (Seis. Omori)	Do.
	10 P.M. (Seis.) Not felt	Do.
" 25th .	7-40 P.M. (Seis.)	Do.
" 30th	23-32 (Seis. Omori)	Do.
	11-34 P.M. (Seis.)	Do.
" 31st .	2 A. M. A sharp shock with minor ones afterwards which lasted over a minute. No damage.	Bajaura and Kulu Valley.
1907, June 2nd .	2-10 A.M. Sharp strong shock about 4 seconds in duration, as if the ground gave way under one's feet. Also recorded at Simla.	Bajaura.

Date.	Time and details of shocks.	Place.
1907, June 2nd .	2-35 A.M. (Seis.) Awakened by the shock.	Simla.
,, ,, .	4-35½ A.M. (Seis. Omori). Distant record lasting 14½ mins.	Do.
,, 13th .	6-5 A.M. A sharp push . . .	Bajaura.
,, 21st .	0-51-24 A.M. (Seis. Omori) . .	Simla.
,, ,, .	1-5 A.M. (Seis.)	Do.
	12-48 P.M. Houses (wooden) rocked and shook. Probably a local shock.	Dunga Gali.
,, 23rd .	2-10 A.M. A sharp shock . .	Bajaura.
	2-5 P.M. Smart shock . . .	Simla.
,, ,, .	14-5-6 (Seis. Omori). Sharp local shock. Maximum displacement of style 16 mm.	Do.
	2-7-P.M. (Seis.) Distinctly felt . .	Do.
,, 25th .	6-10 A.M. A sharp shock, as if ground gave way under one. People ran out of houses.	Bajaura.
,, ,, .	23-34-6 (Seis. Omori). Distant record lasting 26 mins.	Simla.
,, 26th .	11-35 P.M. (Seis.) Not felt . .	Do.
,, 27th .	5-10 A.M. Sharp shock of 5 or 6 secs. duration.	Bajaura.
,, ,, .	5-51-54 A.M. (Seis. Omori) . .	Simla.
	5-53- A.M. (Seis.) Awakened by the shock.	Do.
,, 28th .	6 A.M. Sharp	Bajaura.
,, ,, .	6-53-18 A.M. (Seis. Omori) . .	Simla.
	6-58 A.M. (Seis.) Slight . . .	Do.
	6-15 P.M. (Seis.) Felt . . .	Do.
,, ,, .	18-16 (Seis. Omori)	Do.
,, 29th .	9-15-30 A.M. (Seis. Omori) . .	Do.
,, ,, .	9-15 P.M. (Seis.) Distinctly felt .	Do.
1907, July 4th .	14-53-12 (Seis. Omori) Distant records, origin probably 1,700 miles away. Duration 20 mins.	Do.
,, 9th .	9-5 A.M. (Seis.) Not felt . . .	Do.
,, 12th .	22-52-48 (Seis. Omori) Distant record. Duration 20 mins. . .	Simla. Felt at Ahmedabad.
,, ,, .	10-55 P.M. (Seis.) Not felt . .	Do.
,, 14th .	12-4-54 (Seis. Omori) . . .	Simla.
,, 15th .	16-6-12 (Seis. Omori)	Do
,, ,, .	4-10 P.M. (Seis.) Not felt . .	Do.
,, 17th .	1-36 A.M. (Seis.) Awakened . .	Do.
,, ,, .	1-39-0 (Seis. Omori) . . .	Do.
,, 19th .	3-5 P.M. Sharp from N.E. . . .	Bajaura and Naggar.
,, 27th .	5-50 A.M. Sharp from N.E. . .	Ditto.
,, 28th .	2-5 A.M. Sharp. Sent us out of bed	Ditto.

Date.	Time and details of shocks.	Place.
1907, July 30th .	5-30 A.M. Severe shock lasting 8-10 secs. Houses vibrated.	Bajaura and Naggar.
,, 31st .	8-35 A.M. (Seis.) Very distinctly felt.	Simla.
,, ,, .	8-35-24 A.M. (Seis. Omori) . .	Do.
,, Aug. ,, .	No shocks felt this month . . .	Bajaura and Kalu Valley.
,, 12th .	5-10 P.M. (Seis.) Not felt . .	Simla.
,, ,, .	17-11-12 (Seis. Omori) Tremor lasting 4·4 mins.	Do.
,, 15th .	7-36-12 A.M. (Seis. Omori) . .	Do.
,, 17th .	9-55 A.M. (Seis.) Severe . . .	Do.
,, ,, .	9-56-24 A.M. (Seis. Omori) Local shock	Do.
	9-58 A.M. (Seis.). Slight . .	Do.
1907, Sept. 2nd .	21-42-18 (Seis. Omori) Distant record lasting 1 h. 8 m.	Do.
,, 10th .	10-10 P.M. Moderate shock . .	Bajaura.
,, 12th .	18-7-6 (Seis. Omori) Local . .	Simla.
,, 13th .	11-0 A.M. Moderate . . .	Bajaura.
,, 15th .	23-18-12 (Seis. Omori) Distant shock lasting 22 mins.	Simla.
,, 16th .	4-46-48 A.M. (Seis. Omori) Distant shock lasting 18·2 mins.	Do.
,, 20th .	17-47-30 (Seis. Omori) Local tremor	Do.
,, 23rd .	2 P.M. Moderate	Bajaura.
,, 24th .	17-54-48 (Seis. Omori) Local . .	Simla.
,, ,, .	5-55 P.M. (Seis.) Distinct . . .	Do.
	5-57 P.M. Severe	Bajaura.
,, 25th .	1-25 A.M. Smart	Do.
,, 28th .	14-43-48 (Seis. Omori) Local .	Simla.
,, 29th .	11-5 P.M. Smart, also felt at Mandi .	Bajaura.
,, 30th .	8-15 A.M. Smart	Do.
1907, Oct. 3rd .	10-10 P.M. Sharp from N.N.E. .	Bajaura and Kulu Valley.
,, 5th .	13-24-42 (Seis. Omori) Local . .	Simla.
,, ,, .	1-25 P.M. (Seis.) Long tremor distinct	Do.
,, 9th .	10-45 A.M. (Seis.) Slight . . .	Do.
,, 21st .	6-5 A.M. Sharp and strong shock. Sent people flying out of their houses. Some walls cracked.	Bajaura and Kulu Valley.
,, ,, .	9-56-30 to 10-21-42 A.M. *Bokhara Earthquakes followed by aftershocks.* Registered (Seis. Omori).	Simla.
	10 A.M. (Seis.) Not felt. *Bokhara shock*	Do.
,, ,, .	10-0 A.M. Slight. *Bokhara shock* .	Oghi, Hazara.
,, ,, .	10-15 A.M. Slight. *Bokhara shock* .	Do.
,, 22nd .	8-45 A.M. (Seis.) Slighty felt . .	Simla.
,, 25th .	5-36-30 A.M. (Seis. Omori) . .	Do.

Date.	Time and details of shocks.	Place.
1907 Oct. 25th .	5-40 A.M. (Seis.) Not felt . . .	Simla.
" 26th .	7-49 A.M. Slight	Oghi, Hazara.
" " .	7-51 A.M. (Seis.) Very distinctly felt .	Simla.
" " .	7-53-6 A.M. (Seis. Omori) . . .	Do.
" 27th .	10-48-54 A.M. (Seis. Omori) Distant shock, estimated at 600 miles away. Duration 31 mins.	Do.
" " .	10-50 A.M. (Seis.) Not felt . .	Do.
" 30th .	23-13-30 (Seis. Omori) . . .	Do.
1907, Nov. " .	3 small shocks during the month .	Bajaura and Kulu Valley.
" 2nd .	7-26 P.M. (Seis.) Felt distinctly .	Simla.
" 3rd .	3-46-6 A.M. (Seis. Omori) Distant shock. Duration 14 mins.	Do.
" 13th .	——A.M. (Seis.). Felt in bed . .	Do.
" " .	17-21. Felt	Oghi, Hazara.
" " .	18-44-18 (Seis. Omori) Duration 11·7 mins.	Simla.
" 16th .	6-10 P.M. (Seis.) Not felt . .	Do.
" 22nd .	1 38-12 A.M. Distant earthquake, centre estimated 2,900 miles away, Registered duration 1 hour (Seis. Omori).	Do.
" 30th .	9-40 A.M. (Seis.) Not felt . .	Do.
1907, Dec. 1st .	7-20 A.M. (Seis.) Not felt . .	Do.
" 4th .	Midday (Seis.) Very distinct . .	Do.
" " .	12-2-18 (Seis. Omori) . . .	Do.
" " .	About midday. Of unusual force. The hill-range was shaken, landslips and dust clouds formed. People frightened.	Dharmsala.
" " .	12-2 felt	Lahore.
	1-13 P.M. (Seis.) Felt distinctly. .	Simla.
	3-40 P.M. Sharp shock. People ran out.	Bajaura and Kulu Valley.
" 5th .	11-43-12 A.M. (Seis. Omori) . .	Simla.
" " .	11-45-0 A.M. An upward slanting thrust from the N. Reported by H. Duperney.	Saharanpur.
" " .	11-50 A.M. (Seis.) Felt . . .	Simla.
	9-30 P.M. Sharp	Bajaura and Kulu Valley.
" 8th .	4-3 P.M. (Seis.) Smart . . .	Simla.
" " .	16-5-42 (Seis. Omori) . . .	Do.
" 9th .	12-25 P.M. Slight . . .	Bajaura and Kulu Valley.
" 10th .	1-15 A.M. Slight	Ditto.
	7-28 A.M. (Seis.) Not felt . .	Simla.

Date.	Time and details of shocks.	Place.
1907, Dec. 13th .	4-40 A.M. Caused doors and windows to rattle.	Jaipur.
" 15th .	23-21 (Seis. Omori) . . .	Simla.
" 18th .	4-58 A.M. (Seis. Omori) Distant, duration 15·7 mins.	Do
" 26th .	4-6 A.M. (Seis.) Prolonged tremor .	Do.
" " .	4-7-48 A.M. (Seis. Omori) Duration 16 mins.	Simla, also felt in Kashmir, Kabul and Lahore.
" 30th .	11-19-30 A.M. (Seis. Omori) Duration 8·5 mins.	Simla.

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SUPERINTENDENT GOVERNMENT PRINTING, INDIA
8, HASTINGS STREET



BAZAR, KANGRA BHAWAN.



C. S. Middlemiss, Photo. *Bemrose, Collo. Derby, Inc.*

EARTH FISSURES, KANGRA BHAWAN.



REHLU FORT.



C. S. Middlemiss, Pho.

DAULATPUR.



CHARI VILLAGE.



S. Middlemiss, Photo *Bemrose, Collo., Derby, Eng.*

SHAHPUR.



OLD BRITISH BARRACKS, DHARMSALA.



C. S. Middlemiss, Photo. Bemrose, Collo., Derby, Ltd.

CHURCH, DHARMSALA.



BAZAR, DHARMSALA CANTT.



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McLEODGANJ, DHARMSALA.

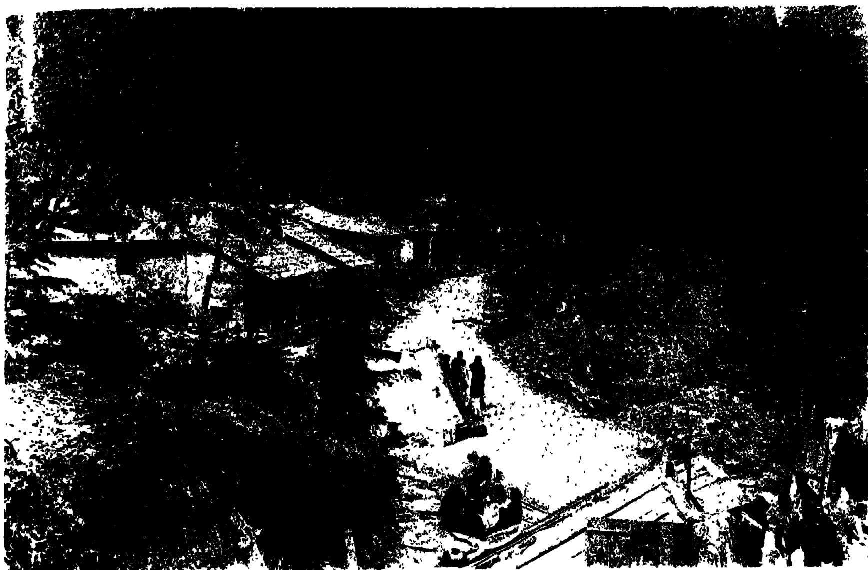


KOTWALI BAZAR, DHARMSALA.



C. S. Middlemiss, Photo. *Bemrose, Collo., Derby, Eng*

JAIL SITE, DHARMSALA.



FORSYTHGANJ, DHARMSALA CANTT



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GURKHA LINES, DHARMSALA CANTT.

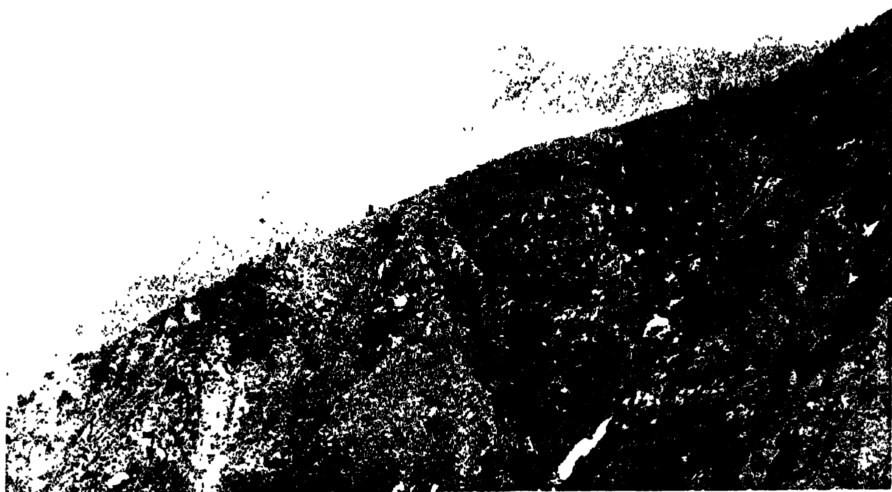


TWISTED MONUMENT, DHARMSALA CHURCHYARD.



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"BRYN," DHARMSALA.

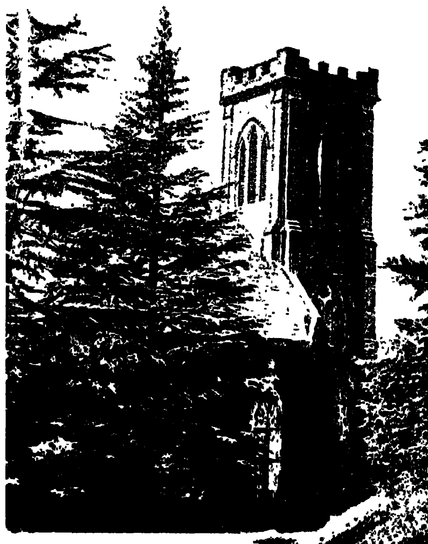


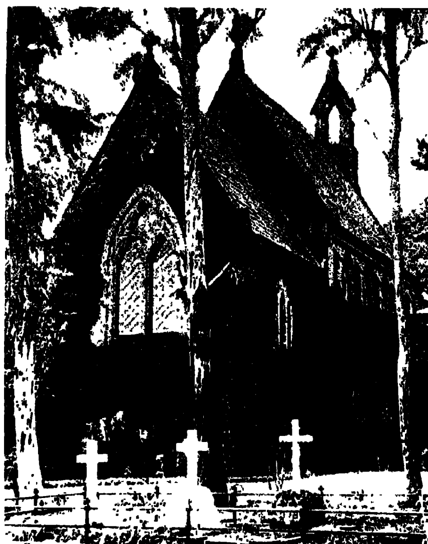
DUST CLOUD AND LANDSLIP, NEOGAL GORGE.



C. S. Middlemiss, Pho. Collo. Derby, Eng.

BAZAR, PALAMPUR





From Old Photos.

DHARMSALA AND PALAMPUR CHURCHES, BEFORE THE EARTHQUAKE.



C. S. Middlemiss, Photo.

PALAMPUR CHURCH.

Bemrose, Collo. Derby, Lo

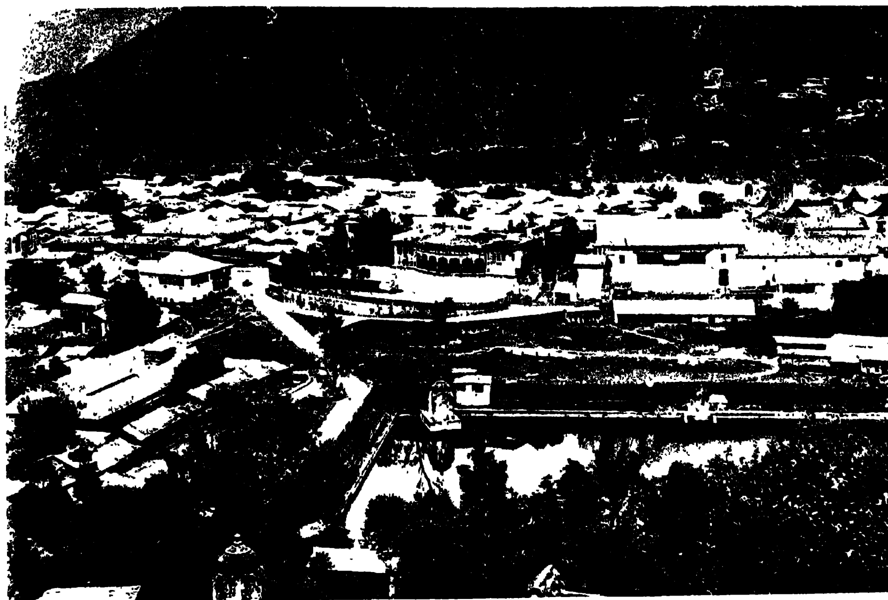


BAIJNATH.



C. S. Middlemiss, Photo. *Bemrose Collo., Derby, En*

JAWALAMUKHI.



A. Gardner, Photo.

MANDI, BEFORE THE EARTHQUAKE.



C. S. Middlemiss, Photo. *Bemrose Collo., Derby, Eng.*

MANDI, AFTER THE EARTHQUAKE.



SULTANPUR, KULU.



C. S. Middlemiss Phot *Bemrose, Collo. Derby, Eng.*

TEMPLE, SULTANPUR.



C. S. Middlemiss, Photo.

TIPRI VILLAGE KULU.

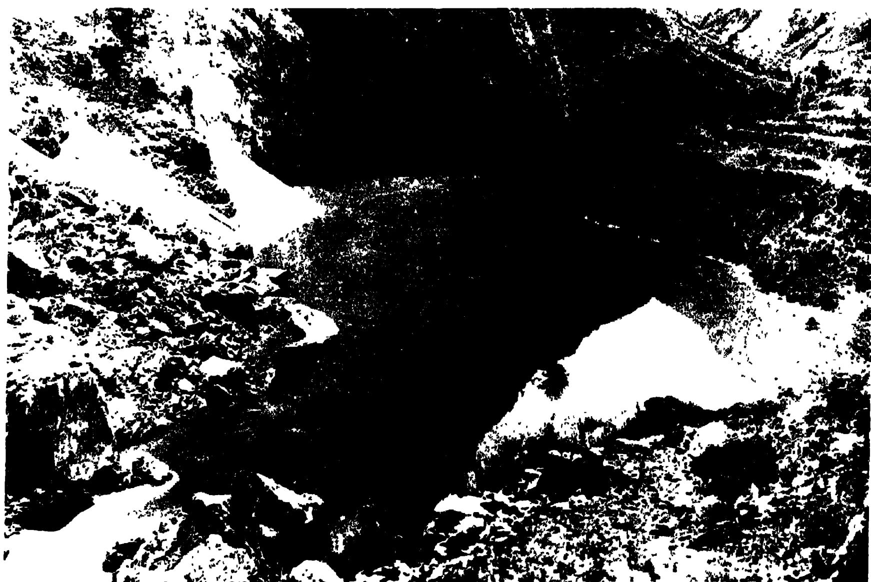


Captain J. Hodgkinson, Photo. Bemrose, Collo., Derby, Eng.

FALLEN ROCK NEAR MANALI.

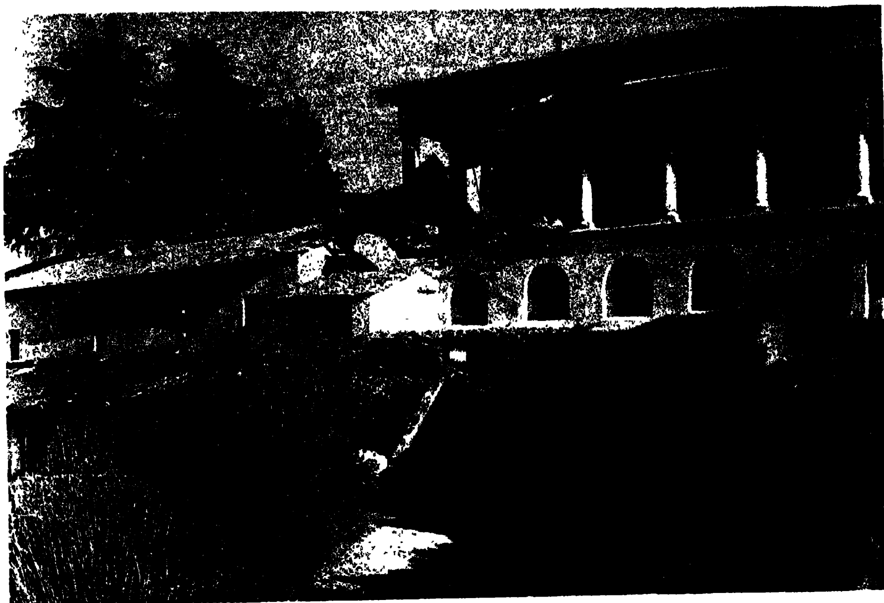


ROCK SLIDES, MALANA GLEN.

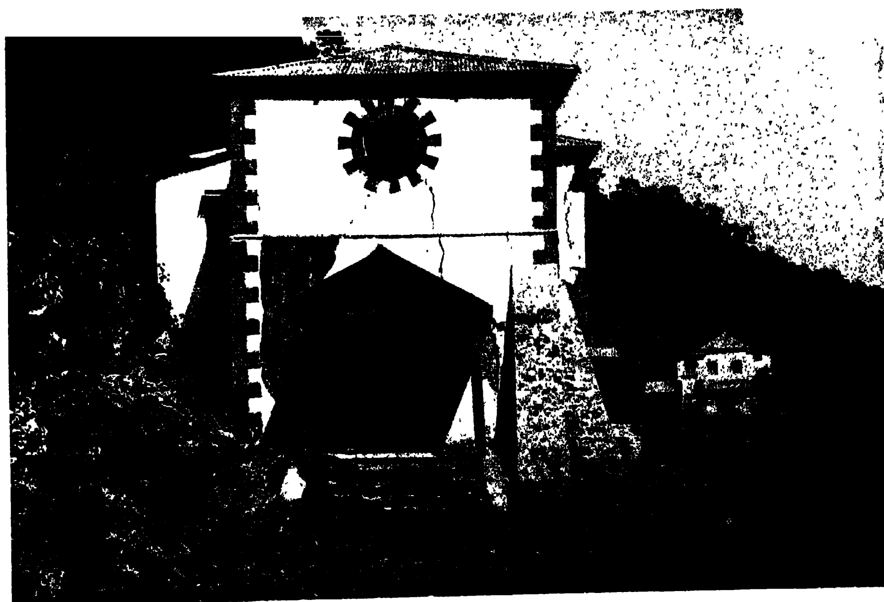


C. S. Middlemiss, Photo *Bemrose, Collo., Derby, Eng.*

LAKE NEAR BARWAR, KULU.



THE CONVENT, MUSSOORIE.



R. R. Simpson, Photo. *Bemrose, Collo. Derby, Eng*

ST. ALBANS, MUSSOORIE.